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To illustrate advantages of a small camera for such subjects as that shown.

AGRICULTURAL MUTUAL CREDIT IN FRANCE AND THE WAR.

[WE extract the following from an article by G. Louée in the *Bulletin des Syndicats agricoles du Jura.* It was these *Syndicats agricoles* that rendered easy the payment of the indemnity in the Franco-Prussian war. It is the spirit of these *Syndicats agricoles* that will enable our allies, with us, to win this great world war: it is the spirit of these *Syndicats agricoles* that, after the war, will raise a greater, a more prosperous, and a more glorious France.—(EDITOR.)]

"The action of the Regional Bank of Mutual Credit of Burgundy and Franche-Comté during the war may be summarised as follows:—At the beginning of the war, the total deposits for which the Regional Bank and the local banks were responsible amounted to the sum of two and a half million francs. The deposits belonged to about 3,000 individuals, all small capitalists and thrifty cultivators, who, having accumulated a small sum of money by dint of toil, were the more liable to the fears that might take possession of the public at the beginning of hostilities.

"These societies found themselves in the same position as the Savings Banks and other institutions of credit that were in direct contact with the savings of the people, and like these they were liable to see their clients insist upon their deposits being refunded.

"Their situation, however, has been quite different: no demands have been made for repayment: there was no need for a moratorium. They have even received, since the beginning of the war, new deposits of the total value of 120,000 francs.

"In the country districts, the people are only too much inclined to believe that debts need not be paid during the war, and one might be inclined to predict that the repayment of small debts would be

suspended, the moratorium having, moreover, deferred the time of their falling due to an undetermined date.

"The agricultural credit institutions of Burgundy and Franche-Comté have upset the least pessimistic forecasts of this kind and proved themselves capable of facing the most critical situations. In fact, the Regional Bank, seeing that the cultivators were realising large sums on account of the requisitions and the rise in the prices of the products of the soil and of cattle, insisted on the local banks obtaining at least partial, if not complete, repayment, whenever the condition of the borrowers permitted it, without in any way involving in difficulties the families of the men mobilised. Since the beginning of the war the sum of 434,000 francs has been received under the head of repaid loans.

"With the deposits entrusted to it, and the repaid loans *plus* the sum standing to its credit with its banker at the beginning of the year and which the banker paid into it, the Regional Bank has bought over 900,000 francs worth of Treasury bonds."

THE HAND-FEEDING AND MANAGEMENT OF BUFFALO CALVES AT A DAIRY.

BY

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Calf raising, though frequently neglected or carelessly carried out, is an important section of dairy management. The importance of the subject is proportional to the milk capacity of the individual buffaloes and cows forming the herd; to the difficulty of procuring, by purchase, substitutes in their place and to the money value which is likely to be got for such animals as it is necessary to sell from the herd. Dairying on modern lines, with due care to hygienic conditions and purity, cannot be worked at a profit by filling up a herd with inferior low-yielding animals and by depending on the number of animals rather than on the quality of the individual for the necessary bulk of milk. When the animals of a dairy herd are individually poor there is little scope for or inducement to the careful raising of the progeny. On the other hand, good milkers are comparatively rare and the present system in many dairies of making no real attempt to raise the calves properly and of depending on the purchase of milk stock from external sources is creating a drain on the supply of good milkers (for example the Sindhi breed of Karachi and the Murrah buffalo of Delhi) and raising the price without any adequate effort to repair or replace the loss to which the milk interests of the future are being subjected.

Given that a foundation herd of carefully selected good milkers is established, due attention to the raising of the progeny, in particular the progeny destined to extend the herd or replace its older members, is both desirable and profitable. A herd which is dependent on purchases for extension and replacement can never really hope to make that definite improvement in individual milk production which is the foundation of profitable dairying. At the same time the chances of the introduction of disease into the herd are much greater in one based on purchase than in one based on home breeding and raising. If it is intended that the future stock be raised in the dairy, the raising must be carefully done. Otherwise the death-rate among the calves will be high and such as come to maturity will fail to maintain the milk producing level of their dams. In the writers' opinion a very fair proportion of the blame for the low yield of Indian buffaloes and cows is to be attributed to the wretched conditions of food and care under which they are raised during the first 7-8 months of their lives, as young calves. It is commonly remarked that she-buffaloes raised in big dairies have seldom, if ever, the milk production of purchased buffaloes from up-country. This is entirely due to the lack of care and sufficient food generally given to calves at such centres. In the writers' opinion and experience, home-raised Delhi buffaloes will give an equal or even better production than their dams, provided a certain amount of care is given in the earlier months of their existence. They can be raised as satisfactorily, if not more so, on a diet of separated milk and a proper substitute, as when allowed to suckle freely. Indeed in certain cases, calf ailments are traceable to the high fat percentage and excessive richness of the dam's milk.

The notes on calf raising which follow are the result of the practice found most satisfactory at the College Experimental Dairy. The system of calf raising outlined here is based on the possession of a herd of medium to good milkers and is restricted to such of their progeny, essentially the female side, which it is intended shall be used for the replacement or the extension of the existing herd or to such as will find a market at a reasonable figure if sold off.

The larger majority of the calves handled by the dairy are buffalo. The buffalo calf is an easier animal to separate from its mother and to hand-feed and the mother is less influenced by the presence or absence of her calf. They are, however, much more delicate than cow calves, and unless care is taken, the mortality may be as high as 75 per cent. Cow calves separated from their mothers can be raised by hand with a little patience though they take to pail-feeding more slowly. Usually, unless the first calf is separated, the maternal instinct of the mother is so strong as to render complete separation of a later calf almost impossible and any attempt to do so produces an adverse effect on the dam's production. Many of the points recorded here are common to both buffalo and cow calves and the methods recommended for raising buffalo calves are equally applicable to cow calves. Since the introduction of these methods in the college herd there has been no mortality among buffalo calves and only one calf died during the period of about twenty months.

For experimental purposes at the dairy and in order to test principles, all calves are maintained alike, though the male buffalo calf receives a slightly lower diet. The male buffalo calf is however an animal which it is scarcely worth raising on any improved lines unless destined as a possible herd sire. Economically, they are more profitable if dead than when alive, and an enquiry into any Indian *gaolee's* business will show that the death-rate among buffalo males is out of all proportion to natural causes and that their natural delicacy, as they are harder to raise than females, is made the most of.

The Dairy deals in both whole milk and milk products. A fair proportion of the buffalo milk is separated. This separated milk provides the basis of the young stock feeding, the balance being sold off.

The high death-rate among young calves, in particular buffalo calves, arises from one or oftener a combination of the following causes:

(1) Lack of sufficiency, regularity and frequency of feeding.

(2) Lack of cleanliness.

(3) Lack of sufficient exercise.

(4) *Absence of care at the time of birth and absence of preventive steps against scour, white scour, worms and bronchial diseases.*

After a few remarks on the condition preceding birth the subject of calf raising by hand will be dealt with from these standpoints.

While in Calf.

In the large majority of cases the average buffalo remains dry for from 2-4 months. In only two cases in the writers' experience has this period been less than one month. The length of time for which the buffalo will remain dry is dependent on the breed, on the individual, on the length of time which elapses between calving and covering, and on the quality of the fodder supply. The general average amongst the breeds on the college farm is for Delhis 10½ months in milk, 2 months dry ; Surtis about 12 months in milk and 3½-4 months dry ; Local (Deccani) about 9-10 months in milk and 4-4½ months dry. Thus the necessity of forcibly drying off so as to permit of 6 weeks' rest is so rare as scarcely to require attention. During the earlier part of this period a good supply of nutritious fodder is all that is essential. If the fodder is of poor quality, as is sometimes the case in the hot weather, a small amount of some cheap concentrated food, for instance undecorticated cotton cake, can be fed. It is a mistaken policy to underfeed a milker during the rest period, more especially if she is a high yielder and if the time of rest between drying off and calving is likely to be short. Rich food is not necessary—only an ample amount of digestible material in the fodder is required. Such concentrated food as may be fed in this period is only to be regarded as making good any defects in this respect in the fodder which the owner is forced to feed. Some 3-5 weeks before calving is due, there should be a small addition given in the form of concentrated. This amount should be increased weekly up to calving time, so that she calves on a rising state of vigour. The length of this period of concentrated food and the amount finally fed in the week previous to parturition are dependent on the length of time the animal has been dry or without direct concentrated food and the probable milk yield of the buffalo

after she has calved. If the animal has been dry for some months this period should begin sooner. If the milk yield expected is high the increments added each week and the mass total in the last week should be greater. The foods available at economic rates in the country are variable and so no very definite recipes can be given. The following, however, will illustrate this principle and be the first step towards a liberal milk supply and a satisfactory calf. First week, give $1\frac{1}{2}$ lb., second week 2 lb., and then one additional pound per week up to the fifth week when the diet will be 5 lb. The concentrated should consist of a mixture of oil-cake with either bran or *chuni* in about equal parts. The period before parturition is an important one—perhaps of more importance from the standpoint of the female's milk yield than from the quality and vigour of the calf, unless the female is particularly badly treated at this period, which unfortunately is too often the case. Generally speaking, the better the feeding of the female, especially if in first calf, without extravagance, the better the chance of a virile calf and a good milk flow; that is, provided the female inherently possesses a good milking tendency.

During and After Calving.

At first sight the care and feeding of the female at this period would appear to have but little direct effect on the calf, specially one which is to be hand-fed. There are, however, one or two points which must be closely attended to or the result to the calf may be fatal. Before parturition is due, say some 3-4 days, the female should be separated from the herd, removed from the common stalls and placed in a calving stall, preferably a loose box. In the writers' opinion a room of galvanized iron, with a removable thatch above the iron roof and having a stone floor, and fitted with a half door for ventilation, is suitable. Such a building is sufficiently cool, is easily cleaned, and can be thoroughly disinfected and is free from ticks. The calving female is made comfortable with litter, which should be removed daily or at any rate cleaned and sunned. During this period the diet should be changed to one of laxative type, foods like cotton seed cake and even to some extent *chuni*,

should be avoided. Probably one of the best diets at this period and for some days after calving is one consisting of half *bajra* and half bran or three parts of the former and four parts of the latter. Oats could no doubt replace *bajra*; but the former is the diet fed by the writers. The amount of this mixture will vary between 4-8 lb. according to the expected milk capacity of the mother. The important points at this stage are a clean spot for calving and a laxative diet to prevent any disturbance in the milk (colostrum) production after calving. One of the commonest sources of loss of calves is navel-ill. This is closely associated with infection from a dirty floor and lack of immediate steps to disinfect and tie up the navel string immediately after separation. A calf dropped in the open rarely suffers from this. and, if a suitable calving shed is not available. probably the next best place to tie up is in the open under shade.

The Feeding and Management of the Calf Immediately After Birth.

The calf should be placed before the mother who will lick it and thus remove most of the mucilaginous matter adhering to it. The calf's mouth and nostrils should be freed of mucilage to permit normal respiration and steps should be taken, as mentioned above, to wash the navel with a 5 per cent. antiseptic lotion and tie it up, using silk thread or gut. If not properly cleaned by its mother the calf may be rubbed down with straw. In some cases the calf may be removed immediately after calving and cleaned down in a separate shed, but there is no direct advantage gained. In about 6-8 hours the female will pass her after-birth and by then the calf will be beginning to attempt to reach the teats. This is a point at which management varies. Some raisers permit the calf to suckle for one or two days, others a week or even longer and others remove the calf entirely. In deciding action certain considerations must be borne in mind. These are (1) the effect of removal on the milk flow of the female, and (2) the effect of non-removal on the aptitude with which the calf will take to hand-feeding later. A certain proportion of she-buffaloes do not appear to be affected by the entire absence of the calf. Others, though not requiring the calf to start

the milk flow, are quieter and more easily handled if their calf is beside them. A few cannot be got to milk unless the calf starts the flow. Usually these are buffaloes which have been permitted in the past to suckle their young. In the case of cows the maternal instinct is greater and a cow which has once been suckled by her calf is difficult to handle in its absence and not infrequently refuses to drop her milk, unless the calf starts the flow. As regards the case of hand-feeding later, there is no doubt that the longer the calves are permitted to suckle, the more difficult it becomes to get them to pail-feed. A buffalo calf, separated from its dam, say a week or 10 days after calving, can be got to pail-feed with little trouble and generally without seriously affecting the milk flow of the dam. A cow calf is extremely difficult to train and, indeed, in some cases, impossible, while the cow, even in her first calf, will probably show a falling off in milk. From these facts the writers believe in the immediate separation of calves, particularly in the case of cow calves. Such separation in the case of the latter is possible only if done at the first calf, before the female has had an opportunity of experiencing the effect. In the case of buffalo it is not so absolutely essential, but, with a view to the greater ease with which the calf takes to the pail, it is probably desirable, unless the udder is caked or out of condition. The mother must of course be thoroughly hand-milked in the absence of the calf. Assuming that early separation is decided on, the calf should get its first lesson in pail-feeding some 6-7 hours after calving. This is done by putting the middle and the fourth finger of the right hand in the calf's mouth. When the fingers are introduced the calf begins to suck, and the hand should then be lowered very gently into a shallow vessel containing between one and two pounds of the colostrum drawn from its mother. In the first efforts the calf draws the milk by sucking on the fingers, but in two or three days it will begin to take up milk from the pail, still assisted by the hand, and within a week will drink direct. During the first 10 or 12 days the calf must get its mother's colostrum. Ordinary milk will not do. During this period it should receive its milk at least 4 times a day. The milk fed immediately after the morning and evening milking needs no special attention.

The milk fed at intervening times must be warmed to about 100-101°F. The vessels in which it is fed must be clean and the milk fed fresh. Neglect of any of the above points will probably lead to stomach troubles. After having its milk, it is advisable to wash the calf's nostrils and mouth with water and wipe them dry.

Calf Feeding.

This section refers to feeding till over, at least, 6-7 months of age. The largest mortality in buffalo calves occurs between the age of 10 days and 4 months. The subject of calf feeding by the aid of separated milk and substitutes is one on which a good deal has been written. The schedule below gives the standard lines on which female buffalo calves and males of possible breeding value are raised at the College dairy. It has worked with complete success for the last two or three years. The variation in the character of the substitutes will be discussed later.

Schedule for Pail-fed Calves.

(All buffalo female calves and males of 2 best milkers.)

I. *Period : length 45 days,* 0-1½*m.*—(*a*) First 10 days, mother's colostrum 4-5 times a day.

(*b*) Remainder of time whole milk up to about 5 lb. fed in 4 meals.

II. *Period : 45 days,* 1½-3*m.*—Whole milk to give way to skim and linseed gruel substitute.

Beginning with 5 lb. whole milk in 3 feeds, skim milk and gruel replace midday meal and later the other two by a process of gradual dilution, till in about 20 days the diet is 5 lb. skim milk. The linseed starts with a few spoonfuls and is eventually raised to about ½ lb. 3 feeds per day. A small quantity of bran and *chuni* is given during this period.

III. *Period : 45 days,* 3-4½*m.*—Continue skim feeding 5-6 lb. with (1) ¾ lb. linseed as gruel followed by 1 to 1¼ lb. bran and *chuni*, or (2) replace linseed and bran-*chuni* by 1 lb. *juar* meal and 1 lb. bran fed after milk. In this period the midday meal should be skim milk with a little linseed gruel or skim milk with a handful of

juar-bran, the bulk of concentrate being fed morning and evening, 3 feeds per day.

IV. *Period:* 45 *days*, 4½-6*m.*—Replace the linseed gruel or a portion of *juar* by cake. Reduce skim milk and cutting out midday meal till in about 10-15 days the milk ceases and the diet is

(1) ½ lb. bran	½ lb. cake	½ lb. *chuni*
or (2) ½ lb. bran	½ lb. cake	½ lb. *juar* meal.

2 feeds per day.

V. *Period:* 45 *days*, 6-7½*m.*—Increase concentrates.

(1) ⅔ lb. bran	⅔ lb. cake	⅔ lb. *chuni*
or (2) ½ lb. bran	½ lb. cake	1 lb. *juar* meal.

2 feeds per day.

VI. *Period:* 135 days, 7½-12*m.*—Reduce concentrates till by 10 months or so, 1 lb. is being fed of either of above mixtures, 2 feeds passing to one.

Fine fodder should be given in the second period and by its close the calf should be consuming a fairly appreciable amount. It should be allowed access to what it requires. The fodder given should be of good quality. It should also be as succulent as possible. If, however, it is unused to succulent material its introduction should be gradual, though eventually it can form a large part of the fodder diet. At the College farm succulent food is met between mid-July and mid-September by grass, mid-September to mid-December by *sorghums*, from mid-December to mid-April by berseem and the balance of the year by silage. Very young calves, if born in the silage period, depend on a small quantity of guinea grass in the early stages of fodder feeding. The milk or separated milk fed should approximate in temperature to about 100°F. Morning and evening feeds immediately after separation do not require special attention, as, at the dairy, separation of buffalo milk for butter or *ghi* purposes follows immediately on milking and the fall in temperature is inappreciable. The midday feed requires warming to about 100-101°F. The linseed is weighed out according to the needs of the stock and made into a gruel, using 1 part of linseed to 6 of water. A quantity of this gruel proportional

to the weight of linseed due to a calf, is then mixed with the skim milk. An important point is that the vessels in which the milk is fed must be kept thoroughly clean and should be scalded as thoroughly as if for human use. Calf illness is not infrequently traceable to lack of care in this respect. The grain feed is weighed out on the same lines, moistened some time in advance and fed by measure after the milk. At feeding time the calves are tied separately; each then receives its portion in an iron bowl. Tying at feeding permits the slower eater to complete without being worried or robbed, prevents calves sucking each other and ensures that each gets its proper share. Attention should be given to the dung, generally passed after feeding, as this affords a fairly ready index of health and the suitability of the diet. It is a mistake to imagine because skim milk is being fed in place of whole milk that a larger bulk of milk is necessary for support. The amounts of milk fed in the schedule are sufficient, and attempts to markedly increase these have generally resulted in diarrhœa.

With regard to the nature of the substitute the writers are of the opinion that up to about the middle of the second period linseed gruel forms one of the best substitutes. After that date considerable variation is possible.

The following experimental feeding illustrates this and is the cause of the duplicate feeds in the schedule. Frequently it may be found to be more economical to use a grain diet. The calves of both groups were alike in age and averaged about 3 months, and up to the date of starting the experiment, both had been raised on separated milk and linseed as outlined.

The diets for groups A and B were as follows:—

	Group A		Group B	
1st period 45 days.	5 lb skim milk		5 lb. skim milk	
	2/3 lb. linseed gruel		1 lb *juar* meal	fed after milk
	½ lb. bran	fed after milk	½ lb. bran	
	½ lb. *chuni*			
2nd period 45 days.	½ lb. *chuni*		½ lb. *juar* meal	
	½ lb. bran		½ lb. bran	
	½ lb. *tilli* cake		½ lb. *tilli* cake	
3rd period 30 days	2/3 lb. *chuni*		½ lb. *juar* meal	
	2/3 lb. bran		½ lb. bran	
	2/3 lb. cake.		½ lb. cake.	

Thus in group A in the first period there was higher proportion of oil and proteid, in group B a higher proportion of carbohydrate. In the subsequent periods A differed from B in having a higher proportion of proteid. All the animals maintained a good condition and the development of the parts of the body was alike. In the first period, animals in B group in the beginning showed some slight tendency to scour and they were at the end perhaps a little softer on handling.

The following are the progressive average gains per head of each group :

	End of 30 days	End of 60 days	End of 90 days	End of 120 days
Group A	18 lb.	38 lb.	68 lb.	92·6 lb.
Group B	31 lb.	59·6 lb.	91 lb.	119 lb.

Group B thus made an average gain per head of 26·4 lb. in 4 months.

The amount fed	A per head	B per head
Skim milk	195 lb.	195 lb.
Linseed	25 lb.	—
Juar-meal	—	93 lb.
Chuni	95 lb.	—
Bran . ..	48 lb.	60 lb.
Cake	49 lb.	49 lb.
Cost Rs.	13-10	12-10
Price per lb. of increase live weight.	2·35 annas	1·70 annas

Feed B thus gave a greater increase and cost 0·65 anna less per lb. As there are considerable divergences in the characters of the two diets a fairly wide margin of food stuffs is apparently possible. The general results bear out similar experiments on cow calves in America.

Housing and Exercise.

Young calves do not require very elaborate housing, at any rate in the Central Provinces. The general calf shed is a galvanized iron building covered with a thatch, protected towards the south-west and north and open towards the east. In the writers' opinion

both the iron and the thatch are important. Iron prevents the existence of harbours for ticks and other parasites and an external thatch makes such a building habitable in the hot weather. The floor of the shed is dry earth and raised about 6″-7″ above the general ground level. It is divided into three compartments and each compartment has a fenced run to the east of the shed, about four times the width of the shed in length. Possibly four sections might be advisable, but are not essential.

In the coldest and wettest parts of the year, the youngest calves are generally housed at night in a large loose box, as, if unprotected, they are subject to broncho pneumonia. In the general shed the chief points to pay attention to are (1) protection against rain and excessive heat, (2) freedom of movement at will, (3) a grading of the calves to each section according to age and size, and (4) cleanliness. In addition to the movement possible in the small paddock, calves should be allowed to go out daily in a neighbouring field in the general farmyard. Ample, though not excessive, exercise is an important item in keeping them fit.

Watering, Salt and Lime.

During the first month or so the calf shows no demand for water —the water in the milk being sufficient ; after this—in particular when they have begun to take up fodder—the need increases. There should be ready access to a clean water supply, preferably in a water trough in the calf pens. If this is not fitted in the calf pens, they should be taken to the water supply at least twice a day in the cold weather and four times a day in the hot. The fact that a calf needs water in addition to what it gets as milk is too often overlooked in rearing calves by hand and causes the calf to gorge the milk with bad effects.

Salt is an essential. It should be supplied in small quantity with the concentrated food. At the same time it is not a bad plan to have a block of rock salt hung in each pen or shed. It

strengthens the appetite and stimulates digestion, a factor of some importance in keeping condition. In the pen in which the calves under three months are kept it is advisable, in addition to rock salt, to hang up one or two blocks of chalk. The young calves will lick these readily. The effect is two-fold—prevention of scour and a prevention of the habit of licking the floors and ground, which is not infrequently the cause of stomach trouble and intestinal worms. The necessity for lime appears to decrease as soon as the diet begins to include an appreciable amount of dry food.

OTHER POINTS OF CARE.

Buffalo calves, generally, are exposed to attacks of hoose, broncho pneumonia, scour, white scour, tympany, intestinal worms, mange and lice. If care is taken on the lines indicated in this article, the possibility of these is very largely reduced. In addition, however, two points might be mentioned which have been found of considerable value in checking mortality. The first is an inspection of the dung and prompt action if anything abnormal is noticed. The second is the administration of preventive doses, at intervals, of raw linseed oil and turpentine.

The following is the schedule of this measure as adopted at the dairy.

Age	Quantity of linseed oil	Quantity of turpentine	
1st month	1 oz.	1/8 oz.	To be administered once every fortnight.
2nd, 3rd and 4th months.	1½—2oz.	1/4 oz.	
5th and 6th months ..	2 —2½oz	1/2 oz.	
7th-12th ,, ..	3 oz.	1 oz.	Administered once a month.

The usual methods of dealing with ringworm, mange and lice need no repetition.

Calves over one year—development of the buffalo heifer. Practically speaking from about 10 months old and onwards, calves require but little special attention as long as they receive

ample digestible fodder, free access to water and exercise. Though inferior or inadequate nourishment should be carefully avoided, the effect of a temporary falling off of this at this time is not so disastrous as in the early stages. Concentrated foods are not essential except under inferior-quality-of-fodder conditions. A certain amount of grain during this period will result in a bigger growth and earlier maturity. A regular grain ration at this period is however too expensive to be economical. Grazing is the cheapest and, if ample, is the best way of raising the calves. At the College dairy, on account of the absence of grazing of any real value, the young stock are raised on fodder. The only advantage of feeding on fodder lies in the fact that the quantity and quality are more regular throughout the year. Most Indian grazing is defective in these respects. If young stock are to be raised on such grass areas it is necessary to reserve some of the area for hay. Cut and store this in October and feed a liberal hay ration between February and the end of July. During this period about a couple of pounds of concentrated is desirable, in order to keep the animals in a thrifty growing condition. The amount of this concentrated will naturally depend on the quality of the roughage. In addition to the hay of the poor local grasses round Nagpur, 2 lb. of cotton seed or 3 lb. of undecorticated cotton cake are found to just maintain heifers in a growing condition at this period. At the College farm, by reason of the inclusion of berseem up to the beginning of April and the better quality of the fodder, concentrates are fed only for about three months, only a pound usually being given. Succulence in the fodder fed has a marked effect in the rate of development. In one case in which the same concentrated diets were used (1) with the dry poor hay available in the hot weather and (2) later with grass in the months of August and September, the average increase in live weight per head over the same time was practically double in the second period. The use of silage as part of the roughage fed in the hot weather can be recommended. A buffalo heifer which has received treatment along these lines will probably be found to weigh about 900—1,000 lb. when $3\frac{1}{2}$ years old before giving birth to her first calf.

Cost of System per head.

		Rs.	A.	P.
1st year	165 lb. of whole milk at 12 lb. per rupee ...	13	12	0
	350 lb. of separated milk at 30 lb. per rupee	11	10	0
	60 lb. of linseed at 15 lb. per rupee ...	4	0	0
	187 lb. of *tilli* cake at 40 lb per rupee ..	4	11	0
	157 lb. of bran and *chuni* at 22 lb. per rupee	7	2	0
	2,430 lb. of fodder at 200 lb. per rupee ..	12	2	0
	Labour per calf (estimating 20) ...	3	3	0
	Shed rental	0	8	0
	Cost for 1st year	57	0	0
2nd year	120 lb. concentrated foods at 40 lb. per rupee ...	3	0	0
	4,440 lb. of fodder at 200 lb. per rupee	22	3	0
	Labour and rental	3	8	0
	Cost for 2nd year	28	11	0
3rd year	180 lb. concentrated foods at 40 lb. per rupee ..	4	8	0
	5,750 lb. of fodder at 200 lb. per rupee	29	0	0
	Labour and rental ..	3	0	0
	Cost for 3rd year	36	8	0
	Total cost per head	122	3	0

If the stock in the second and third years are raised on grazing areas where hay would be cheap the cost per head would not exceed Rs. 95. It might even be possible to reduce the cost slightly further by a reduction of the period on whole milk.

At their first calving, any of the young Delhi and Surti buffaloes on the College farm raised on the above lines are worth Rs. 125-130 and more, if we take into consideration the cost of carriage from the place of purchase.

AMERICAN COTTON AND AMERICAN COTTON SALES IN THE PUNJAB.

BY

W. ROBERTS, B. Sc.,

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COTTON sales have become a feature in the successful introduction of American cotton by the Punjab Agricultural Department. It may therefore be of interest to give some account of them. In a previous article[1] in this journal the writer gave a brief account of the history of the introduction of American cotton in the Punjab Colonies. It was then pointed out that the first sale was started in 1905-6, only three years after the first trial of American cotton. From 1908 to 1913 two sales were held annually, *viz.*, one at Sargodha in the Jhelum Colony and one at Lyallpur on the Lower Chenab. In these early sales the object was merely to help zemindars to get a good price for their superior produce. A small quantity of new seed was imported by the Department yearly from Dharwar in the south of Bombay. Comparatively small quantities of cotton (*kapas*) were brought to these sales, a few hundred maunds as a rule. Premiums up to Re. 1-8 and more a maund were obtained but the effect was to fix the price of American cotton for the whole tract. In 1911 and 1912 factory owners began to pay some premiums independently of the sales. In 1913 the Department was in a position to give out a special variety selected by the Economic Botanist and handed over for further trials to the writer. From 1913 onwards these sales acquired a new importance as it

1 *The Agri. Journal of India*, vol. X, part IV, pp. 343—48.

became necessary for the Department to get back the seed for further distribution. The area sown under this special variety No. 4 F in 1913 was only 100 acres, in 1914 it was 3,000 acres and in 1915 in spite of the effect of the war on cotton sowings the area under 4 F rose to 9,000 acres. In the present season it is estimated that over 30,000 acres will be sown with this variety. In the article previously referred to the writer ventured to prophesy that in spite of the disastrous effect of the war on cotton prices the area under American in the Punjab would not decrease. This was amply fulfilled and something like 65,000 acres was sown with American of all kinds last year. The season, though distinctly bad, was more favourable for American than *desi*. The prices obtained at the sales this year were so good that at a moderate estimate there should be about 120,000 acres sown with American of all kinds in 1916. The above was written during the Meeting of the Board of Agriculture at Pusa (February 1916) and now two months later when cotton sowings have started the whole of the seed with the Department amounting to 2,000 maunds in Lyallpur and Montgomery and about 600 maunds at Sargodha has been already disposed of. Much more could have been sold. Numbers of zemindars, who waited till sowing time before buying seed, have had to be refused daily since April 1st. No better evidence than this is necessary of the willingness of the cultivator to adopt a new thing if it pays him. It is estimated that over 500 maunds seed was retained by last year's growers and hence well over 3,000 maunds of seed has been distributed. The seed rate here is 4 seers per acre and therefore 3,000 maunds means 30,000 acres. The Department now control directly therefore at least $\frac{1}{4}$th of the area. This year's sales were held at five centres, in the Lyallpur circle (as compared to two last year) and two in the Jhelum Colony in the circle of the Deputy Director of Gurdaspur (as compared to one last year). Altogether about 8,000 maunds of *kapas* (seed cotton) was sold at these sales. Of this about 4,500 maunds was first class and was ginned under the Department's supervision for the purpose of getting the seed for distribution. This year some changes were introduced in the conditions of the sales which may have far reaching results. The most important

of these relates to classification of all the cotton by the Department and the leaving of all arbitration in its hands. These conditions were operated with great smoothness throughout and to the satisfaction of sellers and buyers alike.

Another feature of this year's sales was the fact that Messrs. Tata and Sons sent up a representative at the writer's request and it was he who bought the greater part of the cotton either directly or indirectly at the sales.

Very good prices were realized ; in one sale the price paid was Rs. 3-13 more than for *desi* cotton on the same day. The average price per maund of *kapas* in Lyallpur was Rs. 10-12, the price of *desi* being Rs. 7-8. The premium was therefore over Rs. 3. No doubt the war partly accounts for the high price, as imports from America are restricted owing to high freights. Last year, however, when freight was not such a burning question the premium was Rs. 2-13 a maund. In the past season American cotton yielded well per acre as compared to *desi*, though both suffered in yield owing to the excessive drought. The flowers all appear together in the common *desi* cotton grown here and the strain on the plant is enormous at that period. In American, on the other hand, the flowering is much more gradual, and hence the strain at any particular time is less. It was a common sight to see fields of *desi* cotton in July and August strewn with fallen flowers. Zemindars here boldly say American cotton yielded twice as much as *desi*. The extra profit, for 65,000 acres even assuming the American yielded only 1 maund more per acre is over $6\frac{1}{2}$ lakhs without taking into account any premium. The total extra profit to the grower last year may therefore be estimated as 12 lakhs assuming only one-eighth premium per maund.

In the present year with 120,000 acres and assuming a premium of Rs. 2 a maund and an equal yield with *desi*, *i.e.*, an average of 6 maunds per acre the extra profit will be $6 \times 2 \times 120,000$ equal to 14·4 lakhs. No one who knows the facts can doubt the moderation of the above estimate.

It is very satisfactory to note that this cotton is doing very well in the new Canal Colony—The Lower Bari Doab. In one

estate where 250 acres were under this cotton a total yield of close on 2,500 maunds was obtained or nearly 10 maunds per acre. It is estimated that the area under American in this colony this year will be at least 15,000 acres, of which over 10,000 will be pure 4 F.

In Lyallpur one grower this year has 2,000 acres under 4 F cotton It may be pointed out here that not only is the seed being taken by the people from the Department but a very large and increasing number of growers are beginning to pay serious attention to improved cultivation, especially sowing in lines, and interculture—a practice so far quite unknown in the Punjab.

It may be of interest to speculate as to the possible final area of American that can be grown. The average area under cotton in the following districts where American has been successfully introduced is as follows :

	District	Total area irrigated, 1914 15	Total area under cotton, average of 5 years	Estimated area under American cotton in 1916
		Acres	Acres	Acres
Lower Jhelum Canal	Shahpur	892,684	108,439	20,000
Lower Chenab Canal	Lyallpur	1,600,000	158,358	40,000
	Gujranwala	921,411	74,000	7,000
	Jhang	640,594	49,207	35,000
Lower Bari Doab Canal ..	Montgomery	670,428	20,000 (acres in 1915)	15,000
	Other districts			3,000
	Total	4,725,117	410,004	120,000

As the area under cotton in the colonies is generally 10 per cent. of cultivated area, we may expect a big increase in Montgomery. The total area under cotton in the colonies will be roughly 440,000 acres, of which we may expect ultimately 300,000 acres to be under American. A certain proportion of *desi* cotton will undoubtedly continue to be grown especially in very light soils and near the tails of the canals where water conditions are precarious and late sowings are common. In such tracts probably the **Red Sanguineum** *desi* variety or perhaps a *Neglectum* type will be safer to grow.

The amount of American cotton in other districts outside the above is probably not as much as 5,000 acres, though it is being tried widely nowadays practically all over the province.

The marketing of American cotton still leaves much to be desired. The trade is mostly in the hands of Indian ginning factory owners at present, the European firms having done a comparatively small business up to date. Bombay is the chief buyer. What is curious about the business is the almost universal mixing that goes on in the ginning factories. The usual grade sent to Bombay contains from 10 to 30 per cent. of *desi* cotton. Some of the factory owners are very frank over this mixing, and the writer has often seen American cotton with 20 to 30 per cent. of *desi* being added to it before ginning, especially in the Jhang District. One reason for this is that *desi* cotton has a better colour than American and no doubt the mixture looks whiter than pure American. One would expect spinners would find the defect. Individual spinners in Bombay stoutly deny that they want such mixtures, yet that is what they mostly get and pay for.

It might be pointed out that the ginning outturn of all cottons was low last year, and thus there was more than the usual percentage of short fibre. This fact no doubt facilitated mixing with *desi*.

The dangers for the seed from this and other causes will probably make it necessary to brand 4 F bales in future. The point is receiving careful attention. It is satisfactory to note that this year as well as last year a good deal of cotton was sent pure both to Bombay and Nagpur.

The widespread growing of American cotton is brought home to any one walking in any part of the above tract comprising the Lower Jhelum, Lower Chenab, and Lower Bari Doab Canals. There is scarcely a village without a field or two of American, and in some places practically no *desi* cotton can be seen for miles. As an instance of the indirect effect of the cotton sales the case of certain large growers near Lyallpur may be mentioned. Up to the day of our first sale the best price offered to these zemindars was Rs. 10 per maund, whereas the day after the sale they were offered Rs. 11, and some actually sold privately at Rs. 11-4 a maund of *kapas*.

IMPROVED SUGARCANE IN THE UNITED PROVINCES.

BY

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THE Sugarcane Research Station at Shahjahanpur was opened in 1913, and the work of selecting improved varieties of sugarcane was seriously taken in hand in the United Provinces. Results were obtained in a very short time.

The Research Station is fortunate in being situated near a large central factory at Rosa and since results have been available, the staff of the factory have given invaluable assistance in the distribution of improved canes and in testing the results on a factory scale.

The improved cane illustrated (Plate VII) was grown in shallow trenches, 18 inches wide and 6 inches deep with a space of 18 inches between each trench, that is, the cane rows were 3 feet apart. It was manured with castor-cake meal at the rate of 30-40 maunds per acre and irrigated by means of a pumping installation from the neighbouring river.

Before the rains it was earthed up, and it is due to this that the crop remained standing during the abnormally heavy rains and winds of the monsoon of 1915.

The importance of the latter operation cannot be over-estimated. Heavy crops of improved canes grown on the light soils of Rohilkhand that are not earthed up almost invariably fall down during the heavy rains and high winds that prevail during the monsoon in the sub-montane tracts. The quantity and particularly the quality of the *rab* and *gur* are badly affected. In fact it is

impossible to obtain the light coloured *danedar rab* and *gur*, so much prized in the bazaar, from fallen cane.

It is impossible to give an accurate figure of the cost of growing cane, as this depends on many factors that are affected by local conditions, such as cost of labour, price of oil-cake meal and cost of irrigation, etc. The trenching described above costs in the Shahjahanpur District, where labour is not particularly cheap, Rs. 15 per acre and, considering the fact that a crop of improved canes such as that illustrated will yield *gur* and *rab* worth Rs. 350 to Rs. 450 per acre, this additional outlay cannot be called excessive.

The yield of cane in the field illustrated was just over 600 maunds per acre trimmed cane, containing 11·78 sucrose per 100 cane. This was in a year when the outturn of sugar was very low, the *desi* varieties yielding 8-9 sucrose per 100 cane in this district.

The milling properties of the improved cane were tested on a factory scale in a nine roller mill capable of crushing over 500 maunds per hour. Sixty tons of cane were crushed in each test. At the author's request the milling was arranged for without the addition of maceration water in order that the results might be compared with those obtained at the Research Station on a smaller scale. The following results were obtained without maceration at the factory: –

Juice expressed per 100 cane	70·60
Sucrose per 100 juice	14·35
Purity of juice	82·00
Glucose per 100 juice	1·41
Sucrose per 100 bagasse	5·60
Sucrose per 100 cane	11·78
Mill extraction	86·00

These figures are of interest as being the first published of the results that can be obtained on a factory scale with improved canes in these provinces. As already stated, maceration was not employed and the mill extraction (86) would be increased to an appreciable extent by the use of the usual 10-15 per cent. added maceration water. These figures confirm numerous tests that have been made with this cane on a smaller scale at the Research Station with small bullock mills and small power mills.

A medium thick cane (J. 33) selected at the Sugarcane Research Station, Shahjahanpur, for distribut in the Rohilkhand Division of the United Provinces. The photograph was taken in a field grown at the Rosa Factory under the supervision of Mr. H. D. Lang.

PLATE VIII.

Chunni, a local cane of the Shahjahanpur District. The photograph was taken in a neighbouring field grown at the same factory.

Another improved variety of cane, Ashy Mauritius, was grown on a large scale at the factory in 1915. It is a thick variety of the *pounda* type and can only be grown under conditions of intensive cultivation. It has been under experiment in these provinces for 10 years and has given consistently high returns both as regards yield of sugar per acre and quality of *rab* and *gur*. It requires more care in cultivation than J. 33 but it is an excellent cane, well worth a trial where proper care and attention can be given to it. It is one of the very few canes of this type that fully mature during the short growing period of Upper India.

At the Research Station it has given, through a series of years, 100-120 maunds of *rab* per acre.

The milling results obtained in a nine roller mill at Rosa in 1915 without the use of maceration water were as follows:—

Juice expressed per 100 cane	70 90
Sucrose per 100 juice	16·34
Purity of juice	88·30
Glucose per 100 juice	0·57
Sucrose per 100 bagasse	7 10
Sucrose per 100 cane	13 74
Mill extraction	84·30

The author is indebted to Mr. E Simmons for kindly placing at his disposal for publication the two photographs illustrating this article. They were taken at Messrs. Carew & Co.'s Factory, Rosa, in the Shahjahanpur district in the United Provinces.

PHOTOGRAPHIC ILLUSTRATION.

BY

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A LARGE majority of the photographs taken to illustrate scientific writings are reproduced as half-tones, and in order to be successful as illustrations must bear certain characters which are necessary for success with this process although they may not be essential for ordinary pictorial representation as photographic prints. Half-tone reproduction of necessity reduces contrast and in many cases eliminates fine detail, so that it is necessary to aim at a negative in which contrast will be exaggerated, and to produce one on such a scale as will allow the smallest detail required to be shown in the final illustration, to appear sufficiently marked to avoid elimination. This is especially the case with such subjects as include written characters or figures, which in many instances become entirely illegible in reproduction through reduction in scale. It may be well here to point out the advisability of including, in many subjects, a scale of inches or feet, or some object of standard size such as a watch, or for outdoor subjects a figure, without which many photographs both in text-books and scientific memoirs lose illustrative value. For half-tone reproduction what is called a "hard" negative is preferable to one showing fine gradations of tone merging into one another; hardness in this sense means a sharper definition of the edges of the high lights and a greater obvious contrast between the high lights and shadows. Such hardness is entirely wrong in pictorial photography, where the object aimed at is the rendition of atmosphere by means of a fine scale of gradation between the

(a) TAKEN AT MIDDAY JANUARY 25[illegible]

(b) TAKEN AT 4 P. M.

To show advantage of using evening light

Photo-Engraved & printed at the Offices of the Survey of India, Calcutta, 1[illegible]

PLATE

various tones of the picture, this result being attained largely by adapting the style of the negative to the process of printing or *vice versa;* when P. O. P., Bromide, Carbon or Collotype are admissible an entirely different class of negative can be aimed at, but for half-tone reproduction of such subjects as generally come into scientific papers, a soft, evenly gradated negative is not desirable, but rather a hard, vigorous one. It must also be remembered that owing to the "grained" character of the half-tone block, no great range of tone is admissible in pictures to be reproduced by this process, so that in taking out-of-door subjects due allowance must be made for the loss of vigour resulting from the compressed scale of tones. It is unfortunate that in India other more truthful processes such as photogravure and collotype become so expensive, on account of the climate, that they cannot be made use of in our publications so long as considerations of convenience necessitate the use of illustrations produced in this country. It is also to be remembered that the limitations of the half-tone process in many cases render it advisable to make use of line block reproduction in preference thereto. The class of negative suitable for half-tone reproduction can be got in various ways, the chief points to attend to being (1) lighting, (2) exposure and development, (3) class of plate and use of light filters.

Lighting. This is not always under control, but it is generally possible to select a time of day when the subject will be lighted from the side rather than from directly overhead; *i.e.*, the morning or evening rather than midday which in most cases in outdoor subjects will give better contrast. In nearly every case a study of this point will reveal the best time of day for obtaining a vigorous negative, and one which will show those characteristic features of the subject which it is desired to bring into prominence (Plate IX, fig. (*b*), Wheat Plots).

In many cases, such as that illustrated in Plate X (Insect Galls on Leaf) side lighting in place of diffuse or direct illumination is essential for successful representation of the object.

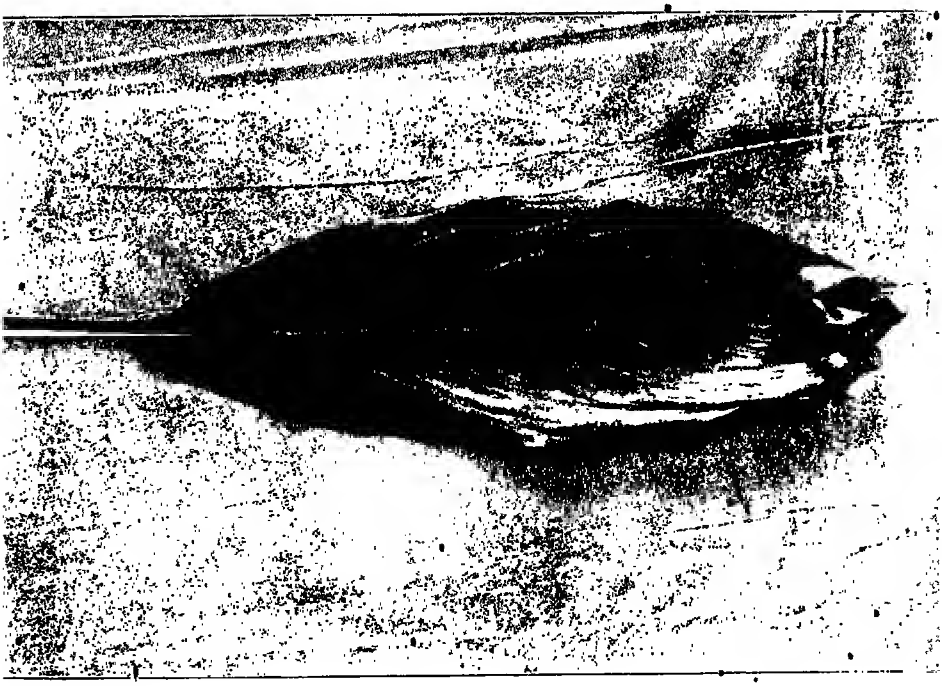
Exposure. This is of paramount importance, as is of course generally recognized, and it is only referred to here on account of the

apparently very general failure to avoid serious errors in this respect; the commonest fault, in the writer's experience, tends to be over-exposure combined with the natural corollary of under-development; this is not so bad a fault as under-exposure and over-development (although the results are very similar) since the photographer is generally unable to stop development before so much of the picture has appeared as will allow of considerable improvement by intensification at the hands of the reproducer. The writer has noticed that a considerable number of amateur photographers in India have so little confidence in their power of correctly estimating exposure that they habitually commence development with only half the quantity of accelerator recommended by the makers of the plate in their carefully calculated developer, and as most of the plates are over-exposed, development is finished with this half strength solution. The resulting negatives are in many cases regarded as good ones by their authors, but they are not of such good quality as would have been attained either by a shorter exposure and development with full strength developer, or with the same over-exposure and development with full strength developer restrained by pot. bromide. It is therefore generally better to give a full exposure, in case of doubt as to how much should be given, and use full strength developer with bromide rather than the method referred to above. The resulting negative is generally hard and the contrasts are sometimes somewhat too violent for the best pictorial effect in ordinary printing, but for half-tone reproduction this is a fault on the right side, provided the hardness is due to slow development and not to under-exposure. It may not be out of place here to draw attention to a point which is liable to escape the notice of those who may have had a considerable amount of successful experience with such open subjects as more generally attract the amateur photographer; when photographing a single object such as a plant in a pot, due allowance is sometimes not made for the very great increase in exposure required by the heaviness of the shadows in such a near object as compared with that of such shadows when a similar plant forms only a small part of the picture in an outdoor subject. For the same reason it is all the more necessary to make

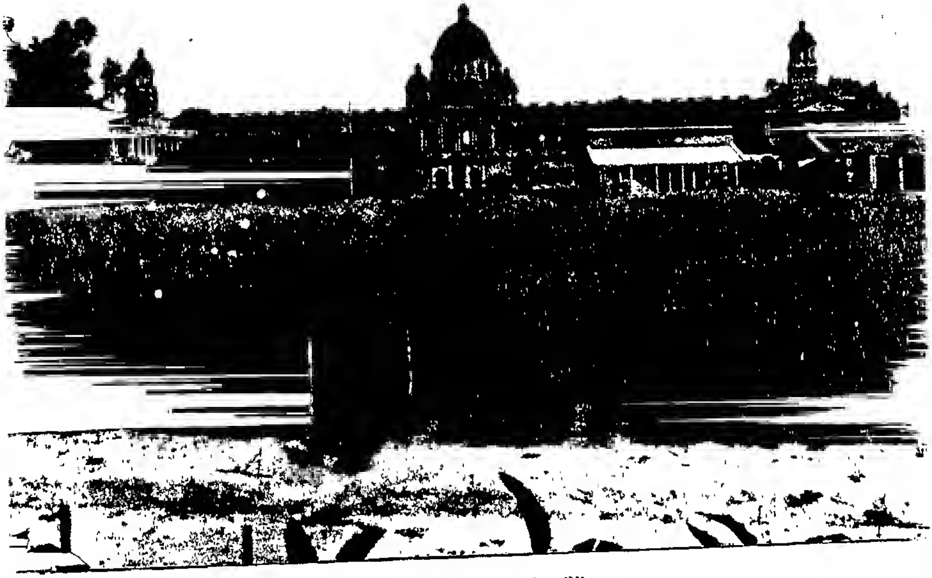
ILFORD ORDINARY

WRATTEN M PLATE AND YELLOW SCREEN WRATTEN K

To show necessity for use of Orthochromatic plates for coloured subjects. Upper butterfly has orange yellow underwing; lower butterfly is sulphur coloured.



OAT PLOTS.



(a) ILFORD ORDINARY.

(b) WRATTEN M PLATE AND RED SCREEN. (WRATTEN A).

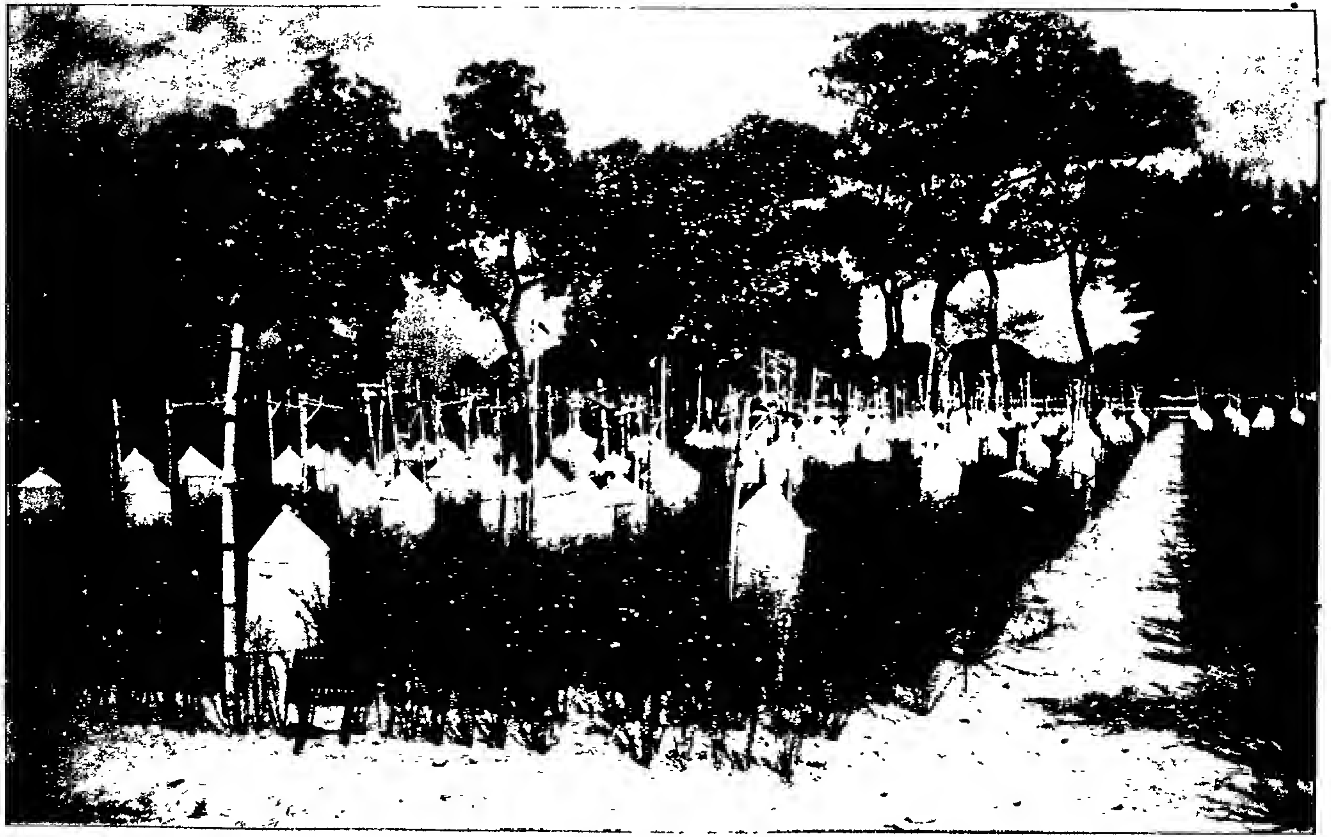
Over correction to show yellow on green.

such allowance when photographing an object (such as a single leaf) so as to reproduce it very nearly life size.

Class of plate. This implies various alternatives, such as slow or rapid, ordinary or orthochromatic, backed or unbacked plates. Films need not be considered, as they are not only expensive but are extremely unreliable in this climate. Generally speaking, slow plates are to be preferred to rapid ones, not only on account of their comparative ease of development and the brilliant negatives which can readily be got from them, but because of the very great latitude of exposure which they permit. This is an inherent quality resulting from their method of manufacture, but is also partly due to the fact that, owing to the comparatively good light in which they can be developed, control of this operation is simplified. Provided a slow plate is not under-exposed a good negative can be obtained from it, under almost any other conditions of exposure, even up to ten or more times that necessary to produce the best result, and as most agricultural subjects admit of time exposures of considerable duration, the use of slow plates may be recommended in preference to fast ones whenever possible. Even in photographing out-of-door subjects which may be affected by wind movement, it may be pointed out that, by stopping down and giving a sufficiently long exposure, a moving branch or crop will, except when the wind movement is considerable, appear sharp in the resulting negative. Furthermore it is very generally true that slow plates are not so liable to deteriorate in the Indian climate as are faster and especially orthochromatic ones, nor do they exhibit so much tendency to suffer from chemical fog due to high temperature of the developer as is shown by the latter class of plate. It is perhaps unnecessary to speak of the greater liability to light fogging which accompanies the use of extra rapid plates, although it may be mentioned as perhaps not being generally known that this may take place through some parts of the materials of the camera and dark slides in bright sunlight, especially the hinged part of the shutter of the dark slide and the leaves of between-lens shutters, which allow a considerable amount of red light to pass through them when made of vulcanite, as they frequently are. It is also worthy of note that slow plates give negatives of much

finer grain than do rapid ones, and this is an important distinction when lantern slides or enlargements are to be made from them. A good many subjects, however, require the use of fast plates in order to enable shutter exposures to be made, and in this connection it might be well to point out the advantages of the small hand camera as being suitable for many subjects which do not demand representation of fine detail but are merely intended to help a written description by pictorial illustration. Many such subjects (*see* Frontispiece) will be found photographically reproduced in the publications of this and other Agricultural Departments, and it may be said that a large percentage of them could have been taken with equal photographic success either on such a small plate as is used in various makes of hand camera or on larger ones such as half plate, but it should be noted that in most cases it would have been very much easier to obtain good results by using the smaller plate, partly on account of the great depth of focus of the short focus lens fitted to small cameras, and partly by reason of the greater number of alternative exposures which it is generally possible to allow when carrying such small apparatus. With regard to the focal length of lenses, it may be pointed out that, although those of short focus possess the advantage of depth of focus, with the accompanying power of giving short exposures at full aperture, this is in many cases more than counter-balanced by the necessary accompaniment of exaggeration of perspective which makes their use inadmissible for such subjects as field crops and experimental plots. On the other hand, for photographing live-stock, especially single specimens, and in cases in which an object in the foreground is to be the subject of interest, a small camera and short focus lens has many advantages, especially when lantern slides are to be made, which can then be done direct without reduction. When views of more extended subjects are required a more just appreciation of the relative sizes of objects in a picture is of course obtained by the use of a long focus lens, and it may be said that for a large class of subjects the use of a telephoto lens will give results very much superior in every respect to those obtainable with the ordinary lens whose focus bears the usual ratio to the diagonal of the plate. Moreover the modern telephoto lens is no longer the

LINSEED PLOTS



WRATTEN M PLATE AND YELLOW SCREEN — WRATTEN K

[illegible]

cumbersome and complicated addition to the camera of a few years ago, but is self-contained, not unduly heavy, and is simple to use; it must not be supposed that its only value is for taking objects necessarily distant; its use for the photography of field crops allows of the representation on the same plate of adjacent plots under differential treatment or bearing varieties of crops, without destroying comparison or contrast by the introduction of the exaggerated perspective almost inseparable from the use of the ordinary lens. A further advantage of the telephoto lens lies in its use for photographing single objects, such as plants, in such a way as to separate them from their surroundings, especially the background. This is the natural result of taking a large scale photograph of such an object with a telephoto lens, which, owing to its design, fails to define any objects except those lying in the single plane for which it is focussed, when used at a large aperture and brought near the object. In the many cases, where the use of an artificial background screen is impossible or difficult, this property is of great value, especially when half-tone is to be used, as any slight differentiation of the background from the subject which may exist in a photograph, is frequently lost in this method of reproduction.

It must be remembered that in reproducing a photograph for illustration it frequently happens that reduction in size of the original is effected in order to save space. In choosing the size of camera and plate this fact should be kept in mind, as whole plate photographs are very generally reduced to half plate size with accompanying loss of detail, so that it may be suggested that the use of a half-plate camera will generally be found advisable in preference to the larger size.

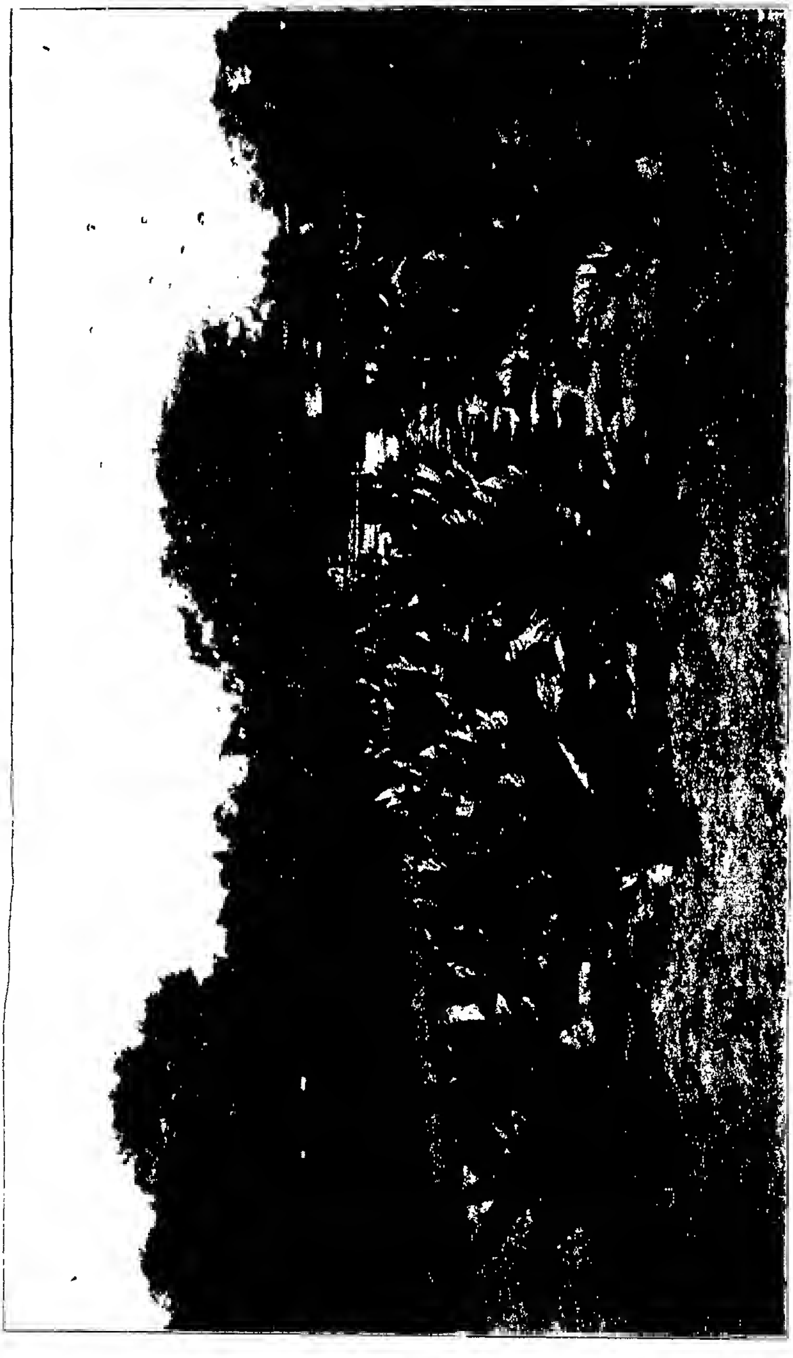
Whilst dealing with lenses it may be well to point out a fact in connection with the use of modern anastigmats which may not be generally known. It is very natural for the photographer to assume that having paid a long price for a good lens, such as an anastigmat, he will find it easier to produce good results than with the old-fashioned Rapid Rectilinear. In England this is generally the case, but in India, where most of our photographs are taken in bright sunlight, we not only lose the principal advantage of the anastigmat, which is designed to enable pictures to be taken in

comparatively poor light by the use of large apertures, but also encounter the disadvantage of "flare;" this is, roughly, the intrusion of sky light by internal reflection in the lens, into parts of the picture where it should not appear, the result in bad cases being patches of light known as flare spots, and in less pronounced ones of general light fog, which gives the impression of over-exposure when developing, and causes many photographers to stop development too soon to allow of the production of contrast. This effect can be avoided by sufficient care in selecting the point of view with reference to the position of the sun, but it may most easily be overcome by the use of an auxiliary lens-hood, the ordinary one supplied with most anastigmats being made, for appearance sake and convenience, much too shallow for safe use in this country. This accessory may be described as almost indispensable in outdoor work in India in connection with most anastigmats, especially when working at or near full aperture.

The advantages of using backed plates are so well known that it is unnecessary to do more than say that many photographers admit their utility but do not use them, partly on account of difficulty in obtaining them, but largely because of fancied trouble in developing them; the latter is really inconsiderable with a good make of plate which can be put straight into the developer without removing the backing, this being got rid of whilst rinsing the plate before fixing. On the other hand, the very great superiority of negatives of outdoor subjects including any strong high lights and still more so of photomicrographs, when taken on backed plates, renders their use almost imperative for such subjects, and not only for interiors including windows, or trees and shrubs against the sky.

Orthochromatic Plates. It is unnecessary to say anything as to the theory underlying the use of orthochromatic plates, but it may be of interest to give some examples of their value, and indeed of their occasional indispensability in illustrating such subjects as are photographically reproduced in agricultural publications. Incidentally it may be remarked that many orthochromatic plates now on the market have a very limited value owing to their comparative insensitiveness to the yellow and red end of the

TOBACCO



ILFORD ORDINARY

WRATTEN M PLATE AND YELLOW SCREEN WRATTEN K.

This is a very difficult subject on account of the heavy shadows on the leaves. It will be seen that these are much more accentuated by the ordinary plate for reasons described in the text.

spectrum, and, where orthochromatism is an advantage, as it is in such a large percentage of cases, it is nearly always worth while to make use of a panchromatic plate. Given correct exposure, a clock, and a thermometer, no more difficulty need be experienced in the development of panchromatic plates than of any others of the orthochromatic variety, and although, as has been pointed out before, the ordinary plate of slow speed is easier to use and may be generally recommended for this reason, no scientific worker will be satisfied to use such plates when convinced that the best photographic representation of an object can only be obtained by means of an orthochromatic plate. Using a panchromatic plate, a light filter may be selected which will correct the superior actinic power of the blue end of the spectrum so as to give correct visual rendering of the subject. Thus in Plate XI fig. (b) the yellow of the butterfly wing is brought out by the use of a deep yellow screen; similarly in Plate XII fig. (b) the black fungal spot on the yellow leaf requires similar colour correction.

In some cases over-correction may be necessary to ensure the appearance of slight colour differences which would otherwise disappear in half-tone reproduction. Plate XIII fig. (b) shows such over-correction due to the use of a red screen; had a yellow screen been used the difference between the ripe and unripe crops although obvious in the negative would not be so in the half-tone reproduction.

One of the most valuable properties of the orthochromatic plate is its power of improving the representation of a field crop without special reference, as in the above cases, to obvious colour differences. This is shown in Plates XIV and XV. It may be of interest to point out why this is so and the reason is made more clear by consideration of the second example (Tobacco Plates XVI and XVII.) Much of the light reaching the lens, in this case, has come through the thickness of the leaves of the crop and, as transmitted light, has undergone absorption, losing some of the blue end of the spectrum. For this reason the ordinary plate can make but little use of it, so that many leaves and portions of leaves which appear well illuminated in the orthochromatic plate are in deep shadow in the ordinary plate, owing to the absence of any large quantity of

reflected light. It may perhaps be relevant to point out that an exposure of sufficient duration to give full value to these heavy shadows, would have resulted in over-exposure of the high lights. In this particular case the use of a panchromatic plate even without any filter would have given a better picture than the ordinary plate, but the additional correction afforded by the yellow screen levels up the shadows and tones down the high lights. A further difference between the rendering power of the panchromatic and the ordinary plate is due to the fact that the light coming from shadowed portions of such subjects as the above is frequently less rich in blue rays and will consequently have less actinic value.

It is useful to remember that orthochromatic rendering may be spoilt by over-correction which may result in *isochromatism*, that is by giving all the colours of the subject an equal luminosity value and thus producing an unnatural effect. This is illustrated in Plate XVIII where the best rendering is obtained on the ordinary plate, the yellow screen used in fig. (b) being too deep in tone and, by reason of its sharp cutting out of the blue end of the spectrum, producing over-correction, and as described above, reducing the shadows in this case to insignificance.

Where adequate representation of an object depends upon accentuation of shadow detail and of contrast between light and shade rather than upon orthochromatic rendering, the use of colour sensitive plates should be avoided as tending to flatten the object by reducing contrast. An example is given in Plate X where oblique illumination is also necessary to give solidity and relief to the representation.

Plate XIX illustrates the value of light filters for producing contrast in photomicrographic representation of objects including fine detail in thin sections, such as the cell walls in the subject reproduced, which without this aid are imperfectly represented. The selection of the appropriate filters must be made with reference to the stains used in the subject.

In conclusion it may be reiterated that for half-tone reproduction a really vigorous photograph is necessary and in order to obtain this the first essential is correct exposure. Until a large amount of

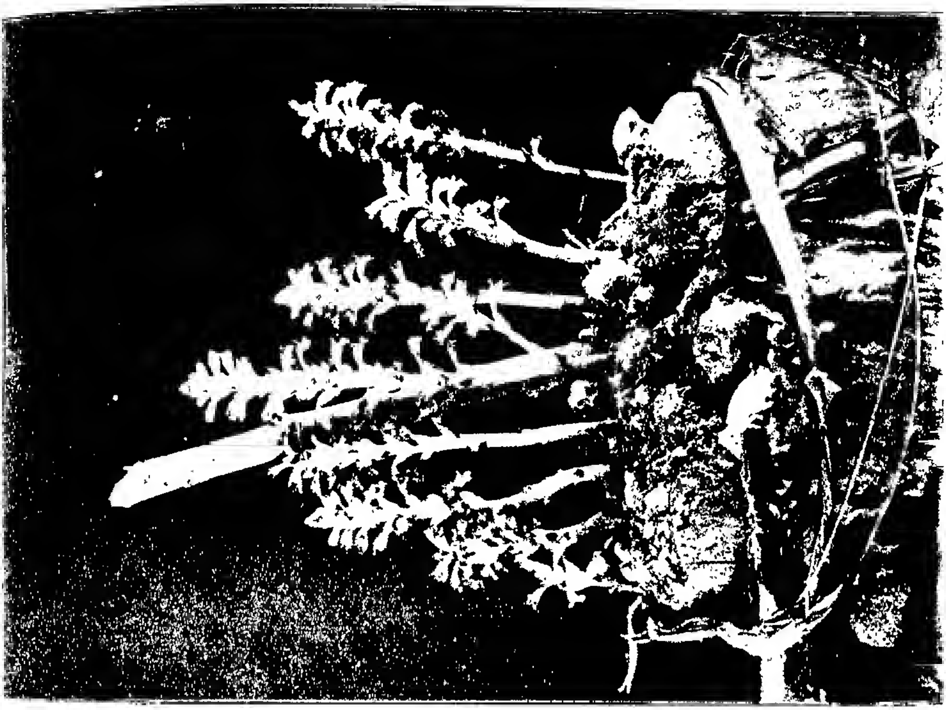
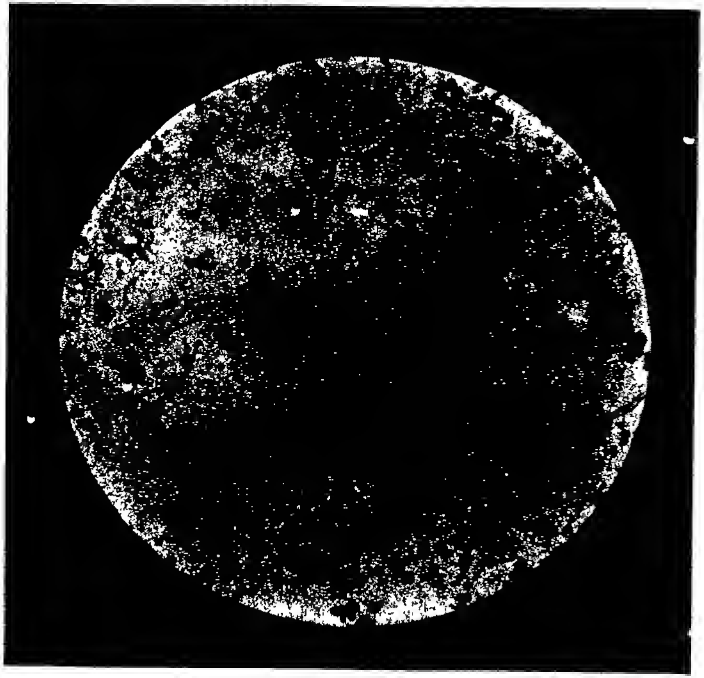
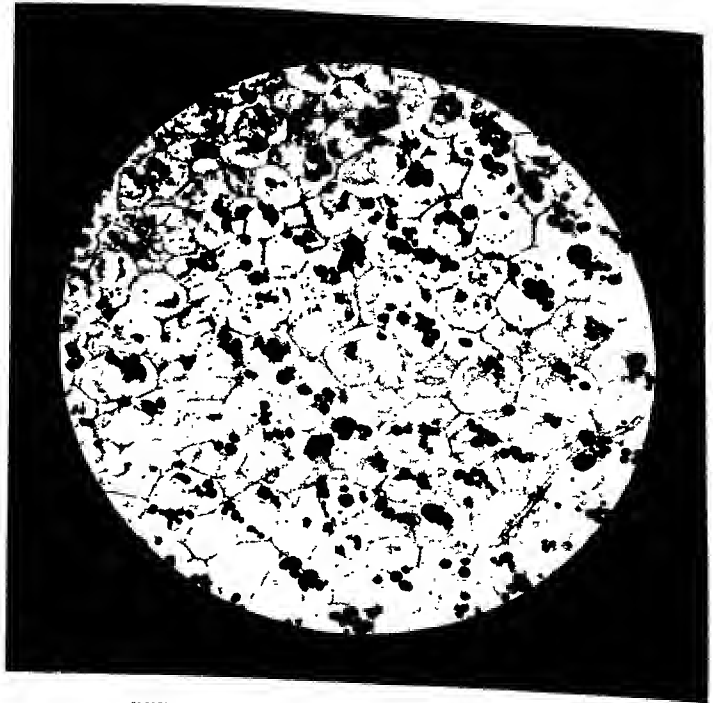


PHOTO-MICROGRAPH OF SECTION OF POTATO TUBER.



(a) NO SCREEN.



(b) GREEN AND YELLOW SCREENS. (WRATTEN B & E.)

Stained Safranin and Hematoxylin. Watson 16 in. to object. Wratten M plate.

experience of photographing subjects similar to the one to be reproduced has been obtained, no photographer can correctly estimate, by guesswork, the proper exposure, and the writer would suggest as absolutely necessary for attaining such experience, the use of a large number of alternative exposures with careful notes of the results; these notes should be kept for reference and use in the future and will be found invaluable. An exposure calculator such as the "Wellcome" supplied by Messrs. Burroughs Wellcome & Co., with their photographic note book, is also most useful, whereas exposure meters depending upon the use of light sensitive paper are practically worthless in India. Standardization of materials and methods by cutting down the number of uncertain factors is also of value; thus the invariable use of one make of each kind of plate required, one kind of developer, and even, so far as is possible, of one lens aperture, will be of help in obtaining results of even value. As a matter of personal experience the writer may strongly recommend the method of development advocated by Messrs. Wratten & Wainwright which does away with inspection of the plate during development, and depends merely upon carrying this on for a length of time determined by the temperature of the developer, the speed of the plate, and the class of negative required, in accordance with a table supplied with each box of plates by this firm. It is claimed that this method will give the best results irrespective of exposure, and with this claim the writer's experience ie in agreement; in addition it may be said that the error of under-development referred to previously will be avoided by this means. With regard to temperature and the special and very serious troubles connected with photography in India arising from this cause, it may be said briefly that when the developer temperature is high the use of pot. bromide becomes necessary and the use of such developers as metol and rodinal whose tendency to produce soft negatives is accentuated under these conditions, is of doubtful expediency. Alum should be freely used, but if ice is available it must be remembered that although a low temperature developer is an advantage, the tendency to frilling is greatly increased by any serious differences in the temperatures of the various solutions through which the plate passes.

THE MANURIAL VALUE OF POTSHERDS.

BY

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Imperial Economic Botanist, Pusa.

1. Introduction.

In previous papers,[1] dealing with certain aspects of soil aeration and surface drainage in India, reference has been made to the effect of adding to the soil porous substances such as potsherds (*thikra*) and fragments of bricks (*rora*). The occurrence of such materials, in sufficient quantity, in a fine alluvial soil has been found at Pusa to exercise a profound influence on the development of the plant and on the yield. Grown on such soils, leguminous crops like gram (*Cicer arietinum*) and Java indigo (*Indigofera arrecta*) produce a deep and copious root-system with abundant nodules as well as heavy crops of well filled seed. Tobacco, when raised on soil rich in potsherds, develops a great mass of fine roots and a heavy yield of leaf. If green-manure is added to such land during the monsoon, the succeeding *rabi* crops benefit markedly.

The explanation suggested to account for these results is a simple one and is based on the fact that the roots of plants as well as the soil organisms require not only a large oxygen supply but also some means of getting rid of the large quantities of carbon dioxide they produce in the soil. Potsherds improve the aeration of alluvial soils and thus afford the means of an increased supply of oxygen and nitrogen in one direction and of the escape of carbon dioxide in the other. When a crop like *sanai* (*Crotalaria juncea*) is ploughed into the ground during the monsoon, a large amount of oxygen is

[1] Soil ventilation. *Bulletin 52, Agricultural Research Institute, Pusa*, 1915, and Soil aeration in Agriculture. *Bulletin 61, Agricultural Research Institute, Pusa*, 1916.

required to complete the decay of the green-manure and vast quantities of carbon dioxide are produced. If this decay is not completed by the time a *rabi* crop is sown, there is present in the soil another competitor for oxygen and another producer of carbon dioxide in addition to the soil organisms and the growing crop. Hence want of oxygen and excess of carbon dioxide may become limiting factors in growth and this would explain why it is that green-manuring so often fails on alluvial soils unless they are surface drained and unless the soil is rich in potsherds. Simple as is this explanation, its complete proof, by the ordinary methods of academic research, is not without difficulty. Several factors, interacting on one another, are involved in such investigations- the plant, the soil, the organisms in the soil, the amount of soil moisture present, the composition of the soil atmosphere in the pore spaces and the nature and amount of the gases and minerals dissolved in the water films surrounding the soil particles. Some of these factors are also influenced by the temperature. To trace the various changes in composition of the atmosphere in the pore spaces and of the dissolved gases in the thin films of water which bathe the root hairs of the plant are matters of the very greatest difficulty. Analyses of the air aspirated from the soil only tell us the average composition of the soil atmosphere. Such methods are obviously far too crude for investigating the changes in the gaseous content of the water films and the relations between this dissolved gas and the general soil air.

While the complete elucidation of the parts played by oxygen and carbon dioxide in the soil are likely to prove both time-consuming and laborious, the fact remains that a considerable amount of evidence exists in favour of the rôle of the potsherd as an aerating agent and of the practical value of this method of soil improvement. It is proposed to refer to a portion of this evidence in the present paper in so far as it relates to the manuring of crops.

2. The waters of Jais.

In February 1915, in the course of a journey through Oudh, some excellent tobacco cultivation was noticed near Jais in the

District of Rae Bareli. Jais is an old Mohammedan city, standing high above the surrounding plain and the mounds on which the town is built are composed of the remains of the ancient city of Udianagar. Large stretches of very fine tobacco (*N. rustica*) are grown on the lower land surrounding Jais and the crop is irrigated from wells. In the present year, I again had occasion to pass Jais and took the opportunity of examining the tobacco cultivation. The soil was rich in potsherds, derived no doubt from broken roof tiles and water pots, and the water used in irrigating the tobacco was said by the cultivators to be unfit for drinking but very good for this crop, in the growth of which they stated very little manure was used. This was remarkable considering the excellent crops and the fact that this plant will not thrive in the absence of abundant nitrogenous food materials. They said the well water was rich in saltpetre and that as many as fourteen waterings are often given to tobacco. A large sample of irrigation water was taken from a well standing in the centre of the tobacco area about a quarter of a mile from the nearest houses, the analysis of which has been carried out by Mr. J. Sen, Offg. Imperial Agricultural Chemist at Pusa who has also kindly furnished me, for comparison, with some analyses of well waters at Pusa. The results are as follows :—

TABLE I.

Analyses of well water from Jais and Pusa.

	Jais	Pusa
Magnesium carbonate	25·39	7·6 to 15·200
Calcium carbonate	—	15·9 to 25·000
Magnesium sulphate ...	10·80	Nil to 1·550
Calcium sulphate	45·50	—
Sodium sulphate	1·01	Nil to 8·300
Sodium carbonate ...	—	4·0 to 9 9.0
Potassium nitrate	34·57	Nil to 0·036 (Potassium nitrate and Sodium nitrate)
Sodium nitrate ...	16·55	
Potassium sulphate	—	1·8 to 5·400
Sodium chloride	45·27	0·9 to 1·600
Total solids	179·09	30·2 to 66·986
Ammonia (free)	0·0212	Nil to 0·032
Ammonia (albuminoid)	0·0143	0·004 to 0·039
Oxygen dissolved	0·7250	0·067 to 0·153

(The numbers refer to parts in 100,000).

Two facts stand out very clearly in these analyses—the high proportion of nitrates in the Jais irrigation water and the amount of dissolved oxygen. In comparison, the Pusa well waters are markedly deficient in these substances. The Jais wells are situated in land exceedingly rich in potsherds, where the aeration of the soil is copious and where there is abundant oxygen for the complete decay and nitrification of the organic matter. It is therefore easy to understand how this well water comes to be rich in nitrates and in dissolved oxygen and why it is so much valued for irrigating tobacco. At Pusa, on the other hand, the alluvium is fine and close and soil aeration is difficult. Here the well waters are poor both in nitrates and in dissolved oxygen and do not possess any particular manurial value. The Jais water, in addition to its high content of nitrates and oxygen, is also rich in potash. This can be accounted for, partly by the fact that in rural centres wood and cowdung are used for fuel and partly by the increased aeration of the soil surrounding the wells due to the quantity of potsherd present. There is considerable evidence for the belief that one of the functions of the fungi of the soil is to collect phosphates and potash for the use of the higher plants.[1] These fungi can only work in the presence of oxygen and therefore the better and deeper the soil aeration the more potash they collect and render available.

Irrigation water, rich in potassium nitrate, is by no means the only condition necessary for raising heavy crops of tobacco of good quality such as the Jais product is said to possess. The soil must also have the proper physical condition for abundant and rapid root development and its tilth must be such that it is not destroyed by frequent surface flooding. Moreover, the crop must be provided with sufficient phosphates as little manure is added to the soil. The presence of abundance of potsherds in the soil would prevent the destruction of the tilth by irrigation and would also facilitate thorough drainage and thus promote aeration. This in turn would provide the soil fungi with oxygen and thus assist indirectly in the collection of phosphates for the tobacco.

[1] Marshall Ward, *Disease in Plants*, 1901, pp. 56 68

The Jais tobacco fields can be regarded as a natural manure factory in which nitrates, potash and phosphates are produced in sufficient quantity for crops like tobacco, maize and poppy which are all grown on the lands in question. In spite of the fact that maize is followed by tobacco or poppy the same year and that a relatively small amount of manure is used, the tobacco crops are luxuriant and the cultivators are obviously prosperous and well-to-do. The sources of the nitrogen and minerals used by the crops are evidently the crop residues and the manure supplied for the maize crop. That this organic matter produces such excellent results is, in all probability, a consequence of the copious aeration of the soil produced by the great numbers of potsherds present. That the crops do not make use of all the nitrates formed is seen by the composition of the well water used in irrigation.

3. Some other Indian nitrate factories.

The potsherd area round Jais is by no means the only natural nitrate factory in India. Well waters, rich in nitrates, occur elsewhere near villages and towns in the plains of India and also in Gujerat.[1] In all cases the aeration of the soils round these nitrate containing wells is good and, in many instances, potsherds or brick refuse occur in large quantities in the immediate neighbourhood.

Natural nitrate factories are common in some tracts of India in the absence of wells. Thus in North Bihar, the manufacture of potassium nitrate is a well-known industry and as many as 20,000 tons of this substance are produced annually.[2] The saltpetre is formed in the so-called nitrous earth and is separated by the *nunias* from other salts which occur mixed with it. This nitrous earth is found mostly *on the high lands round the villages which contain potsherds or brick fragments.* The potassium nitrate is derived partly from organic matter and partly from the ashes of wood or cowdung produced in large quantities in the villages. The abundant soil aeration brought about by the potsherds provides the necessary oxygen for the soil organisms including the nitrate

[1] *Agricultural Ledger*, no. 14, 1895

[2] *The Commercial Products of India*, 1908, p. 972.

producing bacteria. In the presence of organic matter, wood ashes and moisture and under temperature conditions which favour intense bacterial activity, nitrification is rapid and potassium nitrate is produced in abundance. The evaporation of the surface moisture during the dry season, combined with the rise of the subsoil water by capillary action, leads to an efflorescence of saline matter on the ground in which saltpetre is one of the chief constituents. Such accumulations of salts, rich in nitrates, largely occur in areas where potsherds are abundant and are naturally quite different from those met with in alkali lands. One factor, however, which obviously limits production, has hitherto been forgotten in considering these natural nitrate factories. This is the aerating value of the potsherd and the fact that without a copious air supply, rapid nitrification is impossible in the soils of North Bihar.

4. Some practical applications.

The practical applications of these facts to Indian agriculture must now be considered.

The manuring of wells. As is well known, there is a large area of intensive cultivation surrounding the towns and cities of India where large crops of vegetables, sugarcane and tobacco are grown under well or river irrigation. Manure is obtainable, and potsherds are abundant. The manure is usually added to the soil but no use is made of the potsherds. More could be got out of the present supplies of manure and this garden cultivation could be extended by dressing the land with the potsherds and by using some of the organic matter for manuring the wells. It would not be a difficult matter to make, in the soil round a well, a potassium nitrate factory the products of which could be directed either into the well itself or into the irrigation stream. The soil round the well would have to be mixed with the right amount of potsherds and organic matter and ashes would have to be added to the surface soil from time to time. The details would have to be worked out experimentally and then applied to actual working conditions. Possibly some Chemist in the Agricultural Department in search of an interesting problem might consider this question.

The permanent improvement of the land. It is evident that in the soils of India, the great factor in manuring is aeration and that Jethro Tull's great generalization that "Cultivation is manuring" can now be extended and summed up in the phrase—*Manuring is aeration.* The potsherd enables us permanently to aerate the soil and thus make the best use of organic matter including green manures. The potsherd by itself has only a limited value but with the help of small quantities of organic matter, extraordinary results are possible as the example of Jais is sufficient to indicate.

Preliminary experiments have already been completed in the Botanical Area at Pusa which prove that, in the growth of tobacco after green manure, the addition of potsherds to the soil is profitable. With potsherds and surface drainage, a yield of 24 maunds to the acre of cured tobacco leaf has been raised on green manure alone and the produce, cured on the ground in the country fashion, has been sold to the Indian Leaf Tobacco Development Company at Dalsing Serai for fifteen rupees a maund. The value of the crop was therefore three hundred and sixty rupees an acre. To prove the manurial value of potsherds however, something more than small trials at a Plant Breeding Station are required. Accordingly, arrangements have been made to treat ten acres of land on the Dholi estate with potsherds and to compare the produce of the land for some years with the initial capital cost of the treatment. There is little doubt that the results will establish this method of soil improvement and will suggest a useful means for the investment, in the soil of India, of much of the capital now lying idle in the country.

DRY-FARMING AND ITS POSSIBILITIES IN INDIA.

BY

C. V. SANE, B. Ag. (Univ. of Bombay), M. Sc. (Univ. of Wisconsin).

Foreword

Less than a generation ago the very large area of land in Western America, not susceptible of irrigation. was looked upon as practically worthless for agriculture. Since that time many millions of acres of these apparently inhospitable tracts have been converted into fruitful fields. This is due in part to the ventnresome energy of the American people, but chiefly to the careful investigation of the natural conditions of the territory in question and the application to the land of well-known scientific principles, followed by further investigations leading to the discovery of other principles, of profitable application to the reclamation of non-irrigable arid lands.

Colorado established, more than eighteen years ago, a branch station for the study of dry-farming. Utah, a few years later, established a large series of experimental dry-farms. and inaugurated a series of studies on the relation of soils and crops to water. Other states have done similar work, and the Federal Government has conducted for some years very comprehensive dry-farming studies in the great plains area of the United States. On the basis of such work the American people have been able to conquer, without irrigation, much of the great territory lying under a light rainfall in what was formerly known as the Great American Desert.

In talking with students from India it has always seemed that, while the problems of India no doubt differ considerably from those

of western United States, the same process of careful study of existing conditions and the wise applications of scientific principles, old or new, should make it possible to make the agriculture of India, not under irrigation, much more certain than it has been formerly. The problem is a large one, whether in India or America, but the experience of western America leads most of us who have been engaged in the work, to believe that the methods of study followed so successfully in reclaiming the American arid lands may be employed with success wherever a low or uncertain rainfall is a determining condition.

Mr. C. V. Sane, the author of this paper, has spent much time in the dry-farming areas of the United States and has had unusual opportunities to become acquainted with the methods practised on American dry-farms and in dry-farming laboratories. His description of American dry-farming is accurate. He has emphasized the leading principles of the practice. It is to be hoped that the dry-farming regions of India may be helped by such studies and discussions as this one by Mr. Sane, and that especially they may lead to an enlargement of the scientific study of dry-farming under the conditions of India. We of the far west may thus learn much of the far east, and we still have much to learn.

LOGAN, UTAH, U.S.A.
October, 1915.

JOHN A. WIDTSOE.

Introduction.

OF the many things that compel the attention of agricultural investigators in India towards American agriculture, one thing that has done more so than any other is the system of dry-farming and its success in such a short time. By the very nature of things in most cases the little knowledge that we have on the subject is principally derived from books and consequently is very rudimentary. For though the principles of dry-farming are known all over the world the art of manipulating the soil so as to make it an economical practice is fraught with many difficulties. The necessity of dry-farming in India is becoming more and more apparent every day.

However, a detailed study of all the factors—chiefly soil and soil moisture—that are associated with its success in parts where it is an established practice should logically precede the undertaking of such an investigation.

The writer has not only made a careful study of the literature on the subject but has also had the privilege of conferring with persons whose opinions are an authority in the matter, in addition to visits and observations in the fields. A few figures dealing with mechanical analysis, moisture study, etc., have been introduced, for, apart from rainfall which can easily be ascertained, these are the most important factors, knowledge of which is not so easily available in India. They illustrate the basis and extent of the system and will prove of great help in laying out the work. For after all is said and done elsewhere the only way things can be answered definitely is by independent experimenting.

That dry-farming is a world problem is now universally conceded. The following table taken from "Dry-Farming" by J. A. Widtsoe illustrates this fact.

Character of farming	Annual precipitation	Proportion of earth's land surface per cent.
Arid	Under 10"	25·00
Semi-arid	10" – 20"	30·00
Sub-humid	20" – 30"	20·00
Humid	30" – 40"	
,,	40" – 60"	11·00
,,	60" – 80"	9·00
,,	80" – 120"	4·00
,,	120" – 160"	0·50
,,	above 160"	0·50
		100

It will be seen that 55 per cent. of the land surface is under a rainfall of less than 20 inches; thus necessitating the adoption of dry-farming for the profitable growing of crops. It is estimated that about 10 per cent. more receives a rainfall of from 20 to 30 inches, making dry-farming essential. Thus a total of 65 per cent. is directly concerned in the methods of dry-farming. Only a very small portion of this area can ever be completely reclaimed by irrigation practices, leaving the major part of the world always interested in the movement of dry-farming.

The study of this system becomes even more imperative in countries like India where the rainfall over a portion of the country is not only short but extremely precarious, and when one comes to consider the amount of land in India which would benefit by a knowledge of dry-farming it becomes obvious that it is up to us to lose no opportunity of obtaining information which may assist us.

History, definition, and a few contentions regarding Dry-Farming.

Though America has the privilege of bringing dry-farming in limelight to-day, it is not to be supposed that it is a new system. It is rather a new name to a system which was practised in ancient days. Unmistakable proofs have been found to-day in all the ancient civilizations in China, Mesopotamia, Egypt, Mexico, Peru, etc., testifying that it was a practice in vogue in those days. Kearney[1] in a study of dry-land olive culture in North Africa quotes Tunis as an example of the extent to which it must have been practised in the old days. Though Tunis has a rainfall of only about 9 inches on an average, the ancient ruins are of such a nature that the territory was probably densely populated. No evidence of irrigation practice is found and the inference is that the territory must have been dry-farmed. But, however well known the art may have been in the past, the credit of reviving and awakening a general interest in this almost forgotten and neglected practice must be awarded to those American pioneers who wended their way westward and subdued the desert in their struggle for existence. The curious thing in this connection is that these methods were simultaneously and independently developed in Utah, California, Washington, and the Great Plains. However, to Utah belongs not only the claim of precedence in this respect, but also the credit of being the first to undertake a complete study of the behaviour of soil moisture which has given the system a scientific basis it enjoys to-day, mainly through the researches of Dr. Widtsoe and his colleagues.

[1] *Bulletin No. 125 of the Bureau of Plant Industry, U. S. Dept. Agri.*

Dr. Widtsoe defines dry-farming as the profitable production of useful crops without irrigation on lands that receive a rainfall of 20 inches or less. In districts of torrential rains, high winds, unfavourable distribution of rainfall or other water dissipating factors, dry-farming is also properly applied to farming without irrigation under annual precipitation of 25 or even 30 inches. A large part of the dry-farm territory in India will fall into the latter category where conditions of water dissipation are far more pronounced in every particular than the worst that could be obtained in the United States.

Even in the United States, however, there is a considerable difference of opinion regarding the best way of applying the principles of dry-farming to soil management. There comes in the wake of every scientific discovery a time when undiscerning and unscrupulous persons make unwarranted generalizations with consequent failures and confusion, and in a country so much given to speculation and exploitation it must have assumed rather serious proportions to compel the Federal Department of Agriculture to caution the uninformed public against some misconceptions which it would be well to quote here

"In conclusion, the following misconceptions concerning dry-farming may be mentioned as among the most serious: (1) That any definite 'system' of dry-farming has been or is likely to be established that will be of general applicability to all or any considerable part of the Great Plains area; (2) that any hard and fast rules can be adopted to govern the methods of tillage or of time and depth of ploughing; (3) that deep tillage invariably and necessarily increases the water-holding capacity of the soil or facilitates root development; (4) that alternate cropping and summer tillage can be relied upon as a safe basis for a permanent agriculture or that it will invariably overcome the effects of severe and long-continued droughts; and (5) that the farmer can be taught by given rules how to operate a dry-land farm."[1] It is well to keep these in mind in India also.

[1] *Year-Book of the United States Department of Agriculture*, 1911, p. 256.

Some noteworthy facts regarding American agriculture.

An agricultural specialist from America, who had been in India as recently as 1914, observed to the writer that the one thing that struck him more than anything else while there was the very poor physical condition of the soil, an observation that is entirely true. By contrast the condition of American soils ready for planting is almost perfect. But this is due more to the suitable climatic conditions by which good physical condition and preparation of the soil can be secured easily and cheaply Even if the worst came to the worst the soils here over the major part of the continent never dry out or bake so hard that cultivation becomes impossible after the crops have been off the ground for any length of time. As an additional help there are the autumn rains followed by the snow. If conditions do not allow the autumn ploughing of the soil, as the snow thaws in the spring, the soils come in just an ideal condition for preparatory tillage. It is this factor that makes preparatory tillage so easy in America. On the other hand in India where the crops come to maturity, not so much on account of low temperature as is the case here, but due to the sheer lack of water, the roots dry up the soil in such a wholesale fashion that cultivation becomes only possible if attempted below the zone of block formation which is in many cases more than a foot deep, and even after this, the soil never falls into that crumbly condition so essential for good cultivation. Even granting that a deep ploughing is conducive to a better physical condition and a better absorption of water than no ploughing, the only way it could be accomplished is by machine ploughing, which under the present condition of agriculture does not seem easily possible or profitable either. In India we have practically only two sowing seasons : the *kharif* and *rabi*, but these are usually not co-existent, being found in widely separated territories, so that there is but one sowing season in a particular locality and since the farmer is always afraid of a short season the sowing of all crops has to be done post-haste in order that the crops may have a chance to mature. Any one connected with agriculture in India knows how feverishly hurried these operations are. As a contrast,

here in America the farmer is practically farming all the year round, and often starts his crop the year before, as in the case of winter wheat, clover, or sowing in the growing crop in the fall, *viz.*, cowpeas in corn or cotton, etc. Thus he sows his wheat in autumn, it grows a little and rests during the winter under the snow. In spring, when the snow thaws the wheat begins to grow again. In spring, he may sow rye, oats, or barley and seed down the field to clover which may occupy the land from year to year. Different seasons for sowing corn, potatoes, tobacco, clover, wheat and other crops are possible owing to the moisture conditions being such that a great variety of crops could be grown, resulting in the most profitable use of the farmer's time, and in winter, when field operations are at a standstill, he attends to his dairying or stock feeding. Thus conditions are rarely so devoid of the necessity of doing any agricultural work as they are in India with a growing season of only three or four months in each locality, and hard, hot dry weather for the rest of the year preventing crops being taken from season to season under dry-farm conditions.

Other factors are the size of the farms, their contiguity, the presence of the farmer on his estate, the business and competitive condition of farming, the supply of effective machinery, and the large capital available to the farmer for investment. All of these are important, but the peculiarity of the season as explained above, the possibility of distributing crops over a large period and above all the absence of social or religious prejudices such as crop up in every attempt at improvement in India are matters that are not so well realized there and hence are grouped under a separate heading to give them the proper emphasis.

Basis of Dry-Farming.

The theoretical consideration of dry-farming becomes only possible after the water cost of the dry matter is worked out. Extensive researches have been made in this respect by Wollny and Hellriegel in Germany; by Lawes and Gilbert in England; by King and Widtsoe in America and Leather in India. With the exception of Drs. Widtsoe and Leather the rest have obtained

their results under comparatively humid conditions. Making allowance for the excessive use of water used in his work Dr. Widtsoe places the average water cost per pound dry matter at 750 pounds. A dry crop of wheat in India normally yields about 600 pounds of wheat per acre and taking roughly the same weight to represent straw we have a total weight of 1,200 pounds dry matter. The amount of water required for this yield of grain and straw would be 900,000 pounds at the rate of 750 pounds of water to the dry pound. Since one inch per acre is equal to 226,875 pounds the amount of rain actually used by the crop is about 4 inches per acre. There is no doubt that the farmer will be more than satisfied if he can raise 600 pounds of wheat every year with certainty and since the amount actually required represents only from 15 to 20 per cent. of the average rainfall, there is no reason why with better methods of handling the soil than are now in vogue, larger yields could not be secured in normal years or profitable ones in poorer seasons.

It is well known that all the moisture present in the soil is not available to plants. It is only that portion of the soil moisture which can freely move under the force of capillarity that is useful for good plant growth. The point below which the moisture in the soil is not available to crops is designated the wilting co-efficient and the extensive researches of Briggs and Shantz,[1] show that this is a soil constant and bears a constant relation to the hygroscopic co-efficient of the soil and is higher or lower according to the type of soil. Up to a certain percentage beyond this wilting co-efficient even, the water moves with some difficulty and does not replace what is used by the crop as readily. This point, Dr. Widtsoe[2] suggests, should be called Lento-capillarity. In the particular soil he was dealing with he found it to be 12·75 per cent. It is only the difference between this and the field capacity of the soil for holding water that can be safely relied upon for plant growth. The field capacity of the soil does not necessarily come to its maximum capillary capacity owing to the constant pull of gravity. It has been put at 19 per cent. in a clay soil to a depth of 8 feet;

1 *Bulletin No. 230 of the Bureau of Plant Industry, U. S. Dept Agri.*

2 *Bulletin No 115, Utah Agri. Experiment Station*, p. 230.

18 per cent. for the clay loam ; 16 to 17 per cent. for loams and 14 to 14·5 for sandy loams. Considering 7 per cent. as a fair percentage of readily available moisture one acre foot of soil with a weight of 3,500,000 pounds will supply 245,000 pounds of water and a depth of 4 feet of soil would give 980,000 pounds of available water and referring to calculations previously made, a uniform depth of 4 feet of clay loam or loam soil will hold enough moisture to give 600 pounds of wheat per acre. So much, however, depends upon the uniformity of the soil, depth, and its moisture capacity that it is idle to speculate any further until a study of these factors is made actually on the spot and results obtained.

Factors underlying Dry-farming.

The success or failure of dry-farming methods depends on the resultant of the two opposing forces of precipitation and dissipation. Where this margin is large enough for crop production and can be obtained at a reasonable cost, dry-farming will be a success. The system would not be economical though possible where the cost for obtaining this margin will be such as to seriously interfere with the profits. Conservation of moisture at reasonable cost is, therefore, the basis of the system. The positive factors in this retention of moisture are the soil and rainfall and the opposing forces are evaporation, seepage and surface-wash.

Owing to the tropical climate in India over a large part of the year the losses due to evaporation depending upon temperature, sunshine and winds are far more serious than in the cooler climate of the United States. The loss due to seepage is very slight, if any. Owing to the cyclonic and torrential character of the rain, however, our greatest loss in India is in the surface wash, when not only the rain but a considerable proportion of our best soil also is lost with it. There are no figures at hand showing what proportion of rainfall is lost in this way in India but observations made by Briggs and Belz[1] in this country show that as high as 80 per cent. of rainfall of 2·5 inches falling in 4 hours on a nearly level summer fallowed

[1] *Bulletin No. 188 of the Bureau of Plant Industry, U. S. Dept. Agri.*

field was lost by run-off. The only thing that partly compensates for these heavy losses is the comparatively larger rainfall, but whether it is large enough to allow this loss can only be determined by actual tests.

Conditions for water conservation are ideal in Utah where the dissipating forces are comparatively feeble and the character of the precipitation and soil is such as to give maximum efficiency for storing water.

It may be mentioned here that crops in these highly developed dry-farming regions do not depend on one, two or even three feet of soil but search down to a depth of 8 feet or more in the soil in quest of moisture. Not only has moisture percentage been found to have been affected to this depth but wheat roots have actually been traced to a depth of 8 feet. Observations in North Dakota and Nebraska, though different in other respects, show that roots can feed to a depth of 6 feet positively, and possibly at lower depths. It is this deep rooted habit that enables the crop to yield at the rate of 900 pounds of wheat per acre on an average, on a rainfall of less than 15 inches; and crops of 3,000 pounds of wheat to the acre have been raised while 2,400 pounds is not at all unusual.

These factors of the uniformity and depth of the soil which are so essential for success in dry-farming are often lost sight of or not as well emphasized as they ought to be in other parts where attempts at dry-farming are being contemplated.

The subject of soil moisture has nowhere been studied as completely as in Utah and most of the figures reproduced here are therefore drawn from the investigations at the Utah Agricultural Experiment Station.

Professor Chilcott who is in charge of the Office of Dry-land Agriculture of the United States Department of Agriculture divides the dry-farming area in America in two sections—(1) The Great Plains and (2) The Great Basin or Inter-mountain. The Great Plains area lies principally between the eastern slope of the Rocky Mountains and Missouri-Mississippi Valley. It was in this area that the early reverses were experienced and it is this area where a few of the misconceptions quoted above took shape. It is characterized by a scanty winter precipitation, the bulk of the rains coming in May, June, and July.

The Great Basin or Inter-mountain Region lies between the Rockies and the Sierra Nevada Mountains and the precipitation, though usually less in amount, is chiefly received in the winter and spring, leaving the summer rainless. It is in this region that dry-farming was first found successful and subsequently developed to its present magnitude.

Though the moisture study has been made in various parts of the Great Plains and the Inter-mountain Region, the soil study is nowhere as completely done as in Utah. The following table[1] shows the approximate mechanical analysis of the various kinds of soils where dry-farming is successfully practised in this State.

Average mechanical analysis to a depth of 8 feet.

County	Coarse matter	Sand	Clay
Iron County	4·55	31·79	11·91
Juab ,,	6 07	29·53	15·69
San Juan	0·87	56·46	9·15
Sevier	31·31	55·31	11·84
Tooele	7·28	38·65	12 91
Washington	16·28	53·86	10 16

It will be seen that quite a variety of soils can be utilized under the dry-farming system.

The great uniformity of the soil can be seen from the following table[2] representing a depth of 8 feet.

Juab County Farm.

Size of particles	Soil separate	1	2	3	4	5	6	7	8
	Coarse matter ..	9·59	5·29	8·94	4·43	5 85	2·20	3 64	3·93
	Fine matter .	90 41	94·71	91·06	95 57	94·15	97·80	96·36	96·07
0·1—0 32 mm. .	Medium sand ...	8·93	8 99	8 73	11·36	15 69	8 93	16·28	12·60
0·032—0·1 ,, ...	Fine sand ..	20·05	16·48	12·38	18·87	19·48	27·40	25·00	22·52
0·01—0·032 ,, ...	Coarse silt ...	21·97	19·75	22·53	19 06	23·88	22 27	21·88	21·91
0·0032—0·01 ,,	Medium silt	15 23	16 78	17 53	17·25	15·43	13·51	13·73	17·03
0·001—0·0032 ,, ...	Fine silt .	13 25	14·88	14·47	18 93	8·01	7·11	8·68	9·74
less than 0·001 mm. ...	Fine clay ..	15·73	16·88	18·62	20·68	12·41	10·03	12·18	13·29

Soils in the Great Plains area are more variable in character and depth and where shallow or under-lain by a porous sub-soil, results in the conservation of moisture are discouraging.

[1] *Bulletin No. 104, Utah Agri. Experiment Station.*
[2] *Bulletin No. 122, Utah Agri. Experiment Station.*

The limits of soil types in a section of the Great Plains[1] area are as follows :—

Size of particles	Soil separate	1	2	3
1 mm. and above ...	Fine gravel	...	...	...
0·5—1 mm.	Coarse sand ...	0·1-0·4	0·0·2	0·0·1
0·25—0·5 „	Medium sand ...	trace-0·3	0·0·3	0·0·1
0·1—0·25 „	Fine sand ...	1·5-14·1	1·4-12·3	1·6-9·2
0·05—0·1 „	Very fine sand .	43·1-52·5	37·8-55·4	42·7-58·2
0·005—·05 „	Silt	36·1-48·6	32·5-42·7	30·4-46·8
less than 0·005 mm.	Clay ...	5·8-10·5	6 7-11·7	8·1-13·3

The importance of having uniform and deep soils can hardly be over-estimated when it is realized that it is the depth which has made the growth of remunerative crops possible ; by the deep roots they send out in search of moistu[illegible] That the storage of moisture affects to a depth of 8 feet at leas[illegible]d possibly further can be seen from the table[2] reproduced below

All moisture percentage on the basis of dry soil.

Season (after)	Date	1	2	3	4	5	6	7	8	Average
Harvest	Sept. 8, 1902	6·37	7·32	8·17	8 55	8·26	9·29	10·10	10·38	8·56
Storage	Apr. 24, 1903 .	19·29	19·08	18·83	16·99	13·61	12·62	12·24	12 37	15·63
	Increase .	12·92	11·76	10·66	8·44	5·35	3·33	2·14	1·99	7·07
Harvest	Aug. 24, 1906 ...	8·33	7·63	8 12	9·66	11·30	10·75	9·59	7·93	9·20
Storage	May 11, 1907 .	18·17	16 73	17·96	16·88	16 59	16·25	14·98	13·48	16 38
	Increase ..	9·84	9·10	9·54	7·22	5·29	5·50	5·39	5·55	7·18

It has been estimated that on an average more than 60 per cent. of the precipitation could be stored in the soil to a depth of 8 feet in Utah. Burr[3] working on the Western Nebraska soil in the Great Plains area has found that, if properly cared for, the summer-tilled or summer-fallow soils showed from 5 to 7 inches more water in the first 6 feet of the soil than similar land growing a crop and the water so stored has been equal to from 40 to 50 per cent. of the rainfall for the same period. Further that the moisture content of the summer-tilled land increases below the 6 feet area and is apparent to a depth of at least 10 feet.

[1] *Bulletin No. 114, Nebraska Experiment Station.*
[2] Widtsoe, *Dry-Farming*, p. 114.
[3] *Bulletin No. 114, Nebraska Experiment Station*, p. 51.

It is a general impression that soils to be retentive of moisture must be either clayey, clay loams or at least silty loams. That such is not however the case, in fact, a lighter kind of soil is more amenable to dry-farming, is the observation of many.

Professor J. W. Powell in his book "Arid Lands" states that a sandy soil seems to be an essential condition for dry-farming.

Recently Clothier[1] working in Arizona found that "The lighter types of soil have proved to be more valuable for dry-farming than the heavier ones."

That sandy soils are not debarred from dry-farming methods can be seen from actual determinations of soil moisture presented in the following tal [2]. –

Proportion of rainfall stored in the soil.

Soil Type	Percentage of water in soil in autumn (after harvest) depth of 8 feet	Rainfall during the period of conservation in inches	Percentage of precipitation found in the spring to a depth of 8 feet
Sandy loam	8·78	8·51	7·59
,, ,,	7·87	7·94	95·56
,, ,,	8·83	12·14	82·61
,, ,,	9·10	16·17	62·77
,, ,,	11·03	6·38	67·55
Clay	12·34	10·51	93·17
Sand	7·73	7·27	64·80
Loam . .	11·01	10·65	81·13

The observation that lighter types of soil are more suitable to dry-farming is possibly due to the fact that the heavier soils though they have a large moisture percentage, actually allow a smaller supply to the feeding roots, owing to the wilting co-efficient being higher in the heavier soils than the lighter ones.

Burr working with the Western Nebraska soils has found that water above 7 per cent. of the soil only is available to crops. Taking 17 per cent. as the field capacity of the soil, the portion available would be 10 per cent. (17 – 7 per cent.).

The wilting co-efficient of a clay will be somewhere about 11 per cent. and taking its field capacity at 19 per cent. there will

[1] *Bulletin No. 70, Arizona Agri. Experiment Station*, p. 797.

[2] Widtsoe. *Dry-Farming*, p. 121.

be left only 8 per cent. as available moisture. Add to this the effect of the lento-capillary water, the ease with which the roots can penetrate the lighter soils and one can see the reason of the observation under consideration.

So far as the chemical composition is concerned the soils appear to be richer in phosphorus and organic matter. In the following table[1] are given the limits of the percentages in the various dry-farming sections in Utah as compared to a few from India :—

Results expressed as percentage in dry soil.

Ingrediont	1st foot	4th foot	9th foot	India[*]
Insoluble residue	52·14—88·25	52·38—78·29	46·47—86·87	65·16—88·08
Potash K_2O	0·55—1·31	0·45—0·80	0·42—0·70	0·14—1·14
Soda Na_2O	0·14—0·44	0·30—0·52	0·42—0·70	0·01—1·30
Lime CaO	0·56—18·97	3·21—17·83	0·79—20·22	0·13—3·43
Magnesia MgO	0·42—2·24	0·59—2·66	0·75—2·93	0·22—2·47
Sulphuric acid SO_3	0·05—0·13	0·05—0·17	0·07—0·11	not determined
Oxide of Iron Fe_2O_3	2·80—5·42	2·26—5·23	2·36—3·02	2·46—9·27
Alumina Al_2O_3	2·29—6·33	0·14—6·47	3·36—6·62	1·74—13·76
Phosphorus P_2O_5	0·23—0·419	0·12—0·356	0·10—0·284	0·00—0·23
Carbon dioxide CO_2	0·21—18·55	2·04—15·12	0·14—20·08	0·11—1·88
Volatile matter	3·02—5·31	2·79—4·42	1·62—2·93	0·24—6·58
Humus	1·09—1·63	0·50—1·69	1·15—1·35	not determined
Nitrogen	0·057—0·116	0·037—0·1	0·018—0·05	0·015—0·21
Total P.	0·191	0·181	0·112	not determined
Total K.	2·32	1·48	1·30	..

4. Rainfall and its conservation.

In spite of the lower amount of total precipitation, mention has already been made that dry-farming in the Great Basin has proved more successful than the Great Plains area. This is due to the character of the rainfall, more than 80 per cent. of the rainfall in the Great Basin being received as winter and spring rains while more than 60 per cent. in the Great Plains falls after the crops have been sown and over 30 per cent. in summer. The following table shows the average seasonal distribution of rainfall in the two regions :—

Region	Rainfall	Percentage in fall after harvest	Percentage in winter mostly snow	Percentage in spring	Percentage in summer
Great Basin	14·53—19·07	16	23	42	19
Great Plains	11·92—21·30	12	9	43	36

[1] *Bulletin No. 122, Utah Agri. Experiment Station.*

[*] Hilgard. *Soils*, 1912, p. 412

It will be seen that the Great Basin receives 23 per cent. of its precipitation as snow against only 9 per cent. in the Great Plains and it is doubtful if there could be a more ideal condition of storing water if the land is well prepared than the snow, which, as it melts in the spring, gradually seeps through in the soil deep down with no run-off, evaporation, or seepage to speak of. The rainless summer prevents any tendency on the part of the crop to develop surface feeding roots and the plant thus uninterruptedly follows the moisture deep down into the soil.

As regards summer rains, the factors of dissipation in the form of run-off and evaporation are most active at the time the rains come. Besides, while a rainfall sometimes may help to pile the annual average it may not be of any use in increasing the soil moisture a condition to which we in India are well accustomed. Briggs and Belz have observed that a monthly precipitation of 1·9 inches coming in nine light showers was of no practical value, as it all evaporated before penetrating the surface mulch. It has been repeatedly[1] observed that even a rainfall of half an inch does not add to the moisture supply unless followed by others within ten days. As a compensating circumstance, however, of light summer showers, is the fact that a rainfall of from quarter to half an inch may have a decidedly beneficial effect on the crop, though it again becomes a double-edged sword, since it tends to encourage surface roots and in the case of long dry periods specially at a critical period when water is being fast used by the crop, the crops would not have enough time to send down deeper roots and may receive as a result a serious check or possibly end in failure.

It appears that in the long run it would be better if such light showers were prevented from having any effect on the crops in encouraging surface rooting, by deep intertillage and though it might result in a temporary check to plant growth, the ultimate safety of the crop could be more safely assured in case of the long dry periods, which are only too prone to occur in India at some stage of the crop.

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[1] *Bulletin No. 20, Arizona Agricultural Experiment Station*, p. 738.
Bulletin No. 114, Nebraska Experiment Station, p 51

Dr. Widtsoe in summing up the subject says: "A great deal has been said and written about the danger of deep cultivation because it tends to injure the roots that feed near the surface . . . True, deep cultivation when performed near the plant or tree, destroys the surface feeding roots, but this only tends to compel the deeper lying roots to make better use of the sub-soil. When, as in arid regions, the sub-soil is fertile and furnishes a sufficient amount of water, destroying the surface roots is no handicap whatever. On the contrary in times of drought the deep lying roots feed and drink at their leisure far from the hot sun and withering winds and the plants survive and arrive at rich maturity while the plants with shallow roots wither and die or are so seriously injured as to produce an inferior crop.

"One of the chief attempts of the dry-farmer must be to see that plants root deeply. This can be done only by preparing the right kind of seed-bed and by having the soil in its lower depths well stored with moisture, so that the plants may be encouraged to descend. For that reason an excess of moisture in the upper soil when the young plants are rooting is really an injury to them."

B. Absorption and retention of moisture.

Deep ploughing with subsequent tillage and in parts where the rainfall is below 12 inches, summer fallowing to carry over the supply of moisture from one to the other season are the two principal means used for storing water. Nearly all the contradictions with regard to the dry-farming system that have arisen are with regard to these two factors—deep ploughing and summer tillage.

The following presents the view of Professor Chilcott[1] of the United States Department of Agriculture with regard to deep ploughing. "Perhaps one of the most common fallacies is that deep ploughing invariably and necessarily increases the water-holding capacity of the soil Our investigations show that in many instances the receptivity of the soil is governed entirely by the physical condition of the upper 4 or 5 inches, the undisturbed sub-soil being

[1] *Year Book of the United States Department of Agriculture*, 1911, p. 254.

of such a nature over very considerable portions of the Great Plains that it is able to transport downward by capillarity all the moisture absorbed by the surface layer of soil as rapidly as it is accumulated in that layer. Under such circumstances there would manifestly be no increase in either the receptivity or water-holding capacity of the soil if the ploughing were deeper than 4 or 5 inches. Whether this rule will apply to any given soil can be determined only by careful observation, which should extend over a sufficient period of time to include a considerable range of climatic conditions and particularly the varying degrees of intensity and duration of rainfall." Another group of investigators[1] state: "The advocates of deep tillage and ploughing to the depth of a foot to sixteen inches argue that the deep stirring and loosening of the soil creates a greater ability to store water. At none of the Stations in the Great Plains have these claims been justified by the results of experiments."

We have at present in India a wave of deep-ploughing sentiment and the above will certainly afford food for a good deal of reflection and investigation in that connection.

Another interesting and rather unusual statement[2] from one of the experimental stations of the Great Plains area is as follows:—"Advocates of dry-farming systems based on the 'dust blanket' theory strive by maintaining a soil mulch to reduce the loss by evaporation. They reason that by stirring the surface, capillarity will cease to act in bringing up water from the lower depths to the surface. But they fail to take into consideration that because of the absence of a free water table capillarity as a force for moving water upwards ceases and is of no practical importance.[3] The apparent benefits as measured by increased moisture content attributed to the soil mulch, have more than likely been due to the fact that in maintaining the soil mulch, loss of water has been prevented

1 *Bulletin No. 110, North Dakota Experiment Station*, p. 172.

2 *Ibid* p. 174.

3 This statement is not supported by experimental evidence included in this publication: but there is abundant proof of it in data of the Office of Dry Land Agriculture, a part of which has been published by W. W. Burr of that office, in *Research Bulletin No. 5, University of Nebraska*, pp. 75-77.

by the eradication of the greatest dissipators of soil moisture—namely, *weeds.* From the standpoint of moisture conservation cultivation is beneficial when weeds are destroyed or prevented from growing. This fact should not be taken to mean that less cultivation is necessary but rather that such operations should be performed at times when weeds can be combated. If the soil checks and cracks deeply, air is allowed to circulate below the normal drying depth of the surface and cultivation then is necessary. **Otherwise the soil mulch can be disregarded.**" (The heavy type are ours.)

However that may be in other sections, the writer in his visits to the fields in Utah was indeed amazed to find that within 3 to 4 inches of the surface mulch, under a continuous, hard, hot sun, with neither rain nor dew, the soil should be found to be ideally moist for crop growth and that it should be in this condition to a depth of 6 or 8 feet. If the writer had not personally seen this, it would have been difficult of belief, so incompatible appear the dry, hot surface mulch at the top and the cool moist soil below.

Even in the Great Basin region, however, ploughing deeper than 7 to 8 inches has not had any marked effect on the yield or the water stored. In fact as a result of five years' experiments at the Nephi Sub-Station,[1] Utah, no material difference was observed in the yields obtained from the plots ploughed at different depths varying from 5 to 18 inches.

Indeed in the light of these findings, the question of deep ploughing in India deserves more than a casual and theoretical consideration. It may turn out after all that what we want most is deep intertillage rather than deep ploughing.

Speaking of the soil mulch Professor Farrell[2] has drawn attention to the fact that two factors enter in the formation of soil mulch—receptive and retentive. He has shown how in parts where wet and dry periods alternate in rapid succession, the receptive

[1] *Bulletin No. 157. U. S. Dept. Agri. Contribution from Bureau of Plant Industry,* p. 44.

[2] *Dry-Farming,* vol. V, no. 2, p. 245. *The Annual Hand-book of Dry-Farming, 6th International Dry-Farming Congress.*

and the retentive condition of the soil mulch oppose each other. Thus the 'dust mulch' so much advocated by authors in dry-farming becomes actually a hindrance in the effective reception of the precipitation specially in heavier soils, because the fine dust mulch under a heavy rain, runs together and interferes with penetration and occasions an excessive loss by run-off. The run-off in such cases may actually exceed that from a soil which has no mulch at all. Reference has already been made to the observation that 80 per cent. of the rain was lost by surface washing in a heavy rain on a level summer fallow while under the same conditions it was observed that only 40 per cent. was lost on an adjacent stubble field.

In considering the soil mulch therefore in parts where dry and wet periods alternate as in India, both the receptivity and the retentivity of the soil condition should be borne in mind. As a result, in heavy soils it will be safer to leave the surface relatively coarse and lumpy to reduce the tendency for running together and causing a loss by run-off.

Discussions with regard to the value of a summer fallow run quite as hot as on the value of deep ploughing. Thus, results obtained in North Dakota show that while stored water may be of value in supplementing rainfall, it is unable in itself to mature a crop in Western North Dakota; but even here it is admitted that summer tillage has a certain value as insurance against crop failure. Others[1] find it too extravagant a system. Clothier[2] states that summer fallowing by the ordinary methods has not been successful in permanently accumulating water in the soil even after a two-year fallow in Arizona.

It must not be forgotten in this connection that those who advocate summer fallowing do it for a certain set of conditions:—(1) Where the annual rainfall is too small to produce a crop every year, (2) under particular conditions of depth and uniformity of the soil. That such is the case is proved by hundreds of moisture determinations and crop results in the Great Basin. Even here

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[1] *Year-Book of the U. S. Dept. of Agri.* 1911, p. 253.

[2] *Bulletin No. 70, Arizona Experiment Station*, p. 797.

when conditions of soil or rainfall are better, the summer fallow is practised only once in three years. In other places once in four years is found enough. In Kansas it is customary to do so only once in six years.

A modification of summer fallow, which owing to the poor humus content in Indian soils is likely to prove very useful, is the turning under of a green crop in the fallow year. This will not only improve the physical condition of the soil, the chemico-bacterial activities and the consequent liberation of plant food, but will also add to its water-holding capacity on account of the added humus. Experiments so far, however, tend to show that in India it does not pay to turn under huge quantities of green matter unless there is enough water available for complete decomposition of this material and its assimilation by the soil. The aim should be to turn under only as much as would be properly decomposed and assimilated. Even if it is only a slight growth that is ploughed under, it would do more good than a huge mass of loose decomposing matter intercepting the continuity of the soil and upsetting all its useful physical functions.

Choice of crops, Rotations, and Machinery.

Choice of crops. The limited amount of available water naturally requires the growth of only drought-resistant crops. Kearney and Shantz[1] describe drought resistant plants as having the ability either to endure, to evade or to escape drought so as to produce successful crop growth. Ability to endure a drought may be due to the storage of water in the plant-body or ability to become dormant. Of the cultivators' crops, the tendency to become partly dormant is shown by alfalfa and *sorghums*.

The evading of drought can be accomplished by control of transpiration or exceptional root development. Alfalfa with its deep tap root illustrates this point among the cultivated crops.

The adaptation for escaping the drought is illustrated by plants that require a very short growing period before the season of drought begins, such as the early varieties of small grains.

[1] *Year-Book of the U. S. Dept. of Agri.* 1911, p. 352.

However, the crop plants to succeed under dry-farming conditions must possess more than one of the adaptations above mentioned. Thus alfalfa has not only the ability of becoming partly dormant under adverse conditions but can also partly evade drought on account of its deeply penetrating roots. The early varieties of successful small grains have not only a shorter growing season but also are characterized by a small total leaf surface reducing transpiration. The authors mentioned above found that *sorghums* afford the best example among crop plants of a combination of adaptations for meeting drought. They are specially drought evading, and also have considerable power of endurance. In seasons when the rainfall is normal as to total quantity but very irregular in its distribution, while crops like alfalfa and *sorghums* may finally give good yields, corn and potatoes for example which have less ability to become dormant may utterly fail. Thin planting, clean cultivation, cutting and pruning and growing dwarf varieties are other means of evading a drought.

The ultimate object of farming being profitable crop production, such crops must only be grown as are reasonably secured from destruction by drought and which also when grown under the conditions of moisture supply normal to the region, can give a product that will be remunerative to the grower.

It is owing to this factor of profits that wheat is the principal dry-farm crop. Winter wheats wherever possible always give better returns. Of the spring wheats the Durums have become the most popular. In the southern section of the Great Plains Region *sorghum* is found to be the most remunerative and is already a staple crop in parts of Texas, Oaklahoma, Kansas, and New Mexico.

Alfalfa ought to prove a very useful rotation crop in dry-farm regions provided it is not too thickly sown, about 5 to 6 lb. being enough. As a rule dry-farm alfalfa yields well as a seed crop, though, if properly cared for, good hay can also be obtained. *Sorghum* is the third principal dry crop and is likely to extend in cultivation. Other crops like barley, oats, corn, are sometimes used in rotation with wheat in some parts especially in the northern Great Plains area.

A fact that was once overlooked and led to disastrous results is the thin rate of seeding to be used. A thickly sown field may look better at the start but it so depletes the moisture-supply in the soil in the preliminary stage of leaf and stalk formation that very little is left for use at the critical time of forming the grain. Thin seeding is, therefore a very essential factor in successful crop production under dry-farming. 25 to 30 pounds of wheat seed is used to the acre in the Great Basin.

Rotation. No rotation practically exists where summer fallow is practised every year. In some others where the land is fallow once in three years wheat after the fallow and spring barley following the wheat is taken. In some cases when the soil has run down, it is put down to alfalfa for three or four years before growing wheat again.

Machinery. An average holding to make farming pay is supposed to be 160 acres with half the area in fallow every year. In addition to the necessary wagons and hand tools and four horses the following complement of machinery is recommended—a plough. disc harrow, smoothing harrow, drill seeder, harvester or header and mowing machine.

Threshing is always done on contract by travelling tackles.

Power farming is practised on a few unusually large estates, but has not yet become a general feature like power threshing.

One thing more than another which has made dry-farming profitable is the effective machinery which has enabled the farmers to cultivate and farm their lands cheaply. In Dr. Widtsoe's opinion, dry-farming more than any other system of agriculture is dependent for its success upon the use of proper implements of tillage and that if it were not for the invention of labour-saving machinery, it is doubtful whether the reclamation of the great arid and semi-arid regions would ever have been possible. The future as well as the past of dry-farming is thus intimately connected with the improvements already made and to come in farm machinery.

A review of conditions in India.

Such being the factors that control success in dry-farming in America the next point is to consider how we stand in these respects in India. If land is to be prepared efficiently so as to receive and retain the rainfall effectively, costly machinery must be used. In most cases for the present it is beyond the means of ordinary farmers to own these machines for themselves. The only way, therefore, is to use them co-operatively and the great strides that this movement is making at the present ought to make such a co-operative preparation of the soil possible where it is proved by experiment that dry-farming can be profitably pursued.

Conditions of rainfall in India are similar to those of the Great Plains region of the dry-farm section in America. Professor Chilcott describing the variableness of the season in this section says, "Within the area specified, annual precipitation at a given station may easily range during a term of years from as low as ten to as high as thirty inches. It is not an unusual occurrence to have a single torrential downpour of rain which exceeds in amount the normal precipitation for the month in which it occurs. These torrential rains frequently come with such force as to puddle the soil surface, thus making it impervious to water and resulting in the utilization of but a small percentage of the precipitation."

If one had started describing the uncertainty and variableness of rainfall in India, the description would tally word for word, with the difference that every factor mentioned is far more pronounced in India. As every one knows it is the uncertainty and variableness of the rainfall that upsets farming in India and not the smaller amount. Our similarity to the Great Plain region does not consist only in the variableness of the season but also in the fact that all our rain is received while the crops are growing, delivered in about 4 months period technically, but really in not a few days but only a few hours. Our problem thus is unquestionably more difficult to meet, not because of this fact alone, but also because the dissipating forces are very strong. The only thing that serves as a partial off-set is the large amount of our average annual rainfall and possibly our deep soils where such exist in districts of large rainfall.

While discussing the influence of soil in dry-farming, attention has already been drawn to the fact that it is a misunderstanding to suppose that only clayey soils are adapted to dry-farming. In fact as explained above loams and lighter types of soils are even preferred, where they are uniform to a depth of 8 feet or more. In fact this uniformity of character is the corner stone of the dry-farming system. It is this uniformity unhampered by hard-pan or gravel-seam or a murum layer or clayey sub-soil or sticky shale, that gives free scope of movement to the water from one depth to the other. The force of capillarity is uniform throughout ; there is no hard-pan to limit the soil's storing capacity nor a pervious layer to drain off the much needed water down below beyond recovery when needed by the crop, owing to the feeble lifting power of the intervening pervious layer.

The water in such uniform soils simply travels up and down under the influence of capillarity and gravity, but never goes so deep as to be beyond the reach of plant roots. Such deep soils are not infrequent in India and must prove of great value.

It goes without saying that the yields under dry-farming methods are bound to be smaller than in others, and that a kind of insurance must always be paid in the higher cost of using dry-farming methods entailing greater cost of crop production. But dry-farming has succeeded best where a drought is anticipated every year and provision made to fight it. It will never be a success so long as the farmer indulges in the costly temptation of the higher and cheaper but uncertain yields over the admittedly smaller and costlier but certain yields under the dry-farming system.

On theoretical considerations it seems possible that such a certainty of yields can be obtained over quite a large area if dry-farming methods are carefully followed. Experiments on the spot must prove that such is the case.

When found successful, it will practically do away with the crowding in of all agricultural operations in a very small period of the year, leaving the rest unoccupied. It will make farming more evenly distributed and will consequently put a value on the now idle labour of the farmer and will give a certainty to his vocation

It is not a problem that can be solved in one or two years' time, neither is it one that can be successfully met by one cut and dried method. Different soils and climatic conditions will respond to different treatments, and consideration must be given to all these factors. In some, fallowing might be found necessary in a cycle of three or four years. In others it might become necessary every other year. In some cases fallowing with green manuring will have better effect. Some crops might do better in one section and others in others. Fortunately there is no lack of dry-farm crops or varieties in India. Consciously or unconsciously we have been dry-farming most of the time in certain districts. What is wanted is the building up of these crops to constitute a pure strain. Wheat, *juar*, cotton, lucerne, gram, linseed, all will find a place in our system. The point is to experimentally prove what is the best system for given conditions of soil and climate. If there are any means by which something definite can be evolved out of the fickle Indian monsoon they are likely to be the rigorous adaptations of dry-farming principles.

It is a problem that is ever present before the agricultural investigator, the Government and the cultivator, year in and year out. When all the countries in the world—America, Canada, Mexico, Brazil, Australia, Africa, Russia, Turkey, Palestine and even China—have lined up and gone ahead in dry-farming investigations, is it fit that we in India, who would perhaps benefit most from such an investigation, should not be in the forefront ?

ON THE MODE OF INFECTION AND PREVENTION OF THE SMUT DISEASE OF SUGARCANE.

BY

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THE smut disease of sugarcane is caused by the fungus *Ustilago Sacchari Rabenh.* and is easily recognized by the characteristic long whip-like sooty black shoot, devoid of leaves, produced from the top of the affected plant. This is often several feet in length and much curved on itself. In its earlier stages it is covered by a thin silver-white sheath, which later on ruptures and exposes a sooty black dust which consists of the spores of the fungus.

As a rule only the thin varieties like Sanna-bile and Ashy Mauritius[1] are attacked. The thick varieties—Pundya and Red Mauritius, for example—cannot, however, be regarded as altogether immune, as they unmistakably showed the disease on the Manjri Farm during the last two or three years.

Dr. E. J. Butler,[2] in his paper on the "Fungus Diseases of Sugarcane in Bengal," suggested the possibility "that the smut disease can be transmitted both through the infected sets cut from diseased plants which contain living mycelium and also through spores." The same author states further that "experiments in treating this smut are still to be carried out.....Whether it is possible by pickling the sets in copper sulphate or some of the other methods which have proved efficacious against grain smuts, to prevent spore-infection of sound sets remains to be seen."

[1] Ashy Mauritius is originally a thick variety, but on the Manjri Farm it looks more like a thin variety than a thick one.

[2] Butler, E. J. *Mem., Dept. of Agri. in India, Bot. Ser.*, vol. 1, no. 3, 1906.

The experiments described here were suggested by these remarks of Dr. Butler. The object in view was to ascertain how infection usually took place in the field in the case of smut in sugarcane and to test the efficacy of treatment of sets with copper sulphate previous to planting.

The experiments recorded below were carried out during the last three years on the Government Sugarcane Experimentel Station at Manjri near Poona, where smut has been appearing sporadically year after year, particularly on some of the thin varieties. The writer is indebted to Mr. Mahajan, Superintendent of Manjri farm and to Messrs. Padhye and Sane, Graduate Assistants on the same farm, for looking after the experimental plots and much help during the progress of the experiments.

Experiment No. 1.

1912–1913.

Method. Careful search was made for stools entirely free from smut in the Ashy Mauritius plot and sixty sets fit for planting were selected from these. Another lot of sixty sets was cut from canes which had distinctly shown the smut. The healthy and diseased sets were further divided into two lots of thirty sets each and one half were steeped in copper sulphate solution of 2 per cent. strength for fifteen minutes and the other half was left untreated. The sets were then planted in four plots as follows :—

Plot No. I	...	Diseased sets 30, steeped.
Plot No. II	.	Diseased sets 30, unsteeped.
Plot No. III	...	Healthy sets 30, steeped.
Plot No. IV	...	Healthy sets 30, unsteeped.

The sets were planted on the 13th of Decembar 1912. The plots were chosen in a part of the farm far removed from any standing sugarcane. The soil was virgin soil[1] broken up for the first time for this experiment.

Observations. The germination was uniform in all the plots except No. IV, where only a few shoots came up.

[1] This remark does not hold good for the other experiments that follow.

The first case of smut observed was on 13th March 1913 and it occurred in plot No. 1.

In May 1913, smut was found in all the plots except in No. III.

No. III remained smut-free till November 1913, when three smutted shoots were observed in it.

It was not possible to make an exact count of the smutted shoots in all the plots, yet it was observed that No. II suffered the most and No. III remained smut-free the longest and suffered the least.

Remarks. The results of the experiment pointed to the following conclusions :—

(1) Infection may be carried in diseased sets, as indicated by the behaviour of plot No. I.

(2) Steeping sets in copper sulphate solution is not, by itself, sufficient to prevent smut; indicated by the plots Nos. I and III.

The appearance of smut in plot No. IV which had sets from healthy canes in it may be due either to infection by spores adherent to the sets or dormant mycelium in the sets resulting from direct aerial infection by wind-borne spores on parent canes, though the latter showed no external signs of it.

Experiment No. 2.

1914-1915.

The experiment of 1913-1914 was repeated, using a hundred sets to each of the four plots as in the following table :-

Plot No.	Treatment	Date of planting	Germination on 1-4-14	First appearance of smut on	No. of smutted shoots on 13-2-15
I	Healthy sets, steeped in copper sulphate 2 per cent. strength for fifteen minutes.	27-2-14	17 shoots	21-5-14	3
II	Healthy sets, unsteeped	27-2-14	159 ,,	29-5-14	122
III	Diseased sets, steeped as above	27-2-14	2 ,,	21-5-14	2
IV	Diseased sets, unsteeped	27-2-14	109 ,,	21-5-14	28

Remarks. Steeping was found to retard germination seriously and had no effect in preventing smut. A regular count of the number of healthy shoots at the end of the experiment was found impracticable in this as in the other experiments recorded here owing to excessive tillering; hence the proportion of smutted to healthy shoots could not be ascertained. Yet the figures for smutted shoots give a clear indication that smut appears to the greatest extent in those plots which had sets from diseased canes planted in them. It has to be remembered in interpreting these figures that the germination in the plots Nos. II and IV was much better than that in the corresponding plots Nos. I and III. When corresponding plots only are compared, the infective power of diseased sets becomes quite apparent. The appearance of smut in plots with healthy sets in them again suggests infection by spores adherent to the sets or by dormant mycelium in apparently healthy canes resulting from direct aerial spore-infection.

Experiment No. 3.

1915–1916.

The experiment of 1913-1914 was repeated using a hundred eyes for each plot and using two strengths of copper sulphate for steeping. There were, therefore, six plots in this experiment as under:—

Plot No.	Treatment	Date of planting	Germination on 13-3-15	First appearance of smut on	No. of smutted shoots on		TOTAL
					31-8-15	12-2-16	
I	Healthy sets, steeped in 2 per cent. $CuSO_4$.	13-2-15	7 shoots	?	Nil	5	5
II	Healthy sets, steeped in 1 per cent. $CuSO_4$.	13-2-15	14 ,,	19-5-15	,,	Nil	0
III	Healthy sets, unsteeped	13-2-15	48 ,,	19-5-15	1	3	4
IV	Diseased sets, steeped in 2 per cent. $CuSO_4$.	13-2-15	3 ,,	21-4-15	1	0	1
V	Diseased sets, steeped in 1 per cent. $CuSO_4$	13-2-15	3 ,,	15-4-15	6	121	127
VI	Diseased sets, unsteeped	13-2-15	13 ,,	1-4-15	15	77	92

Remarks. These results confirm generally those of the two previous experiments. They indicate that the disease is most surely conveyed through the use of diseased sets. Steeping is again seen to be ineffective in checking smut and moreover affects germination seriously. Only three of the diseased sets treated with 2 per cent. copper sulphate solution came up and one of them showed the disease. Plot No. III with healthy sets in it has practically remained healthy without steeping.

EXPERIMENT No. 4.

1915–1916.

Objects. To determine if smut spores adhering to the surface of sets are able to carry the disease and also to observe the effect of copper sulphate solution on adherent spores.

Method. Smut spores were smeared on to the surface of 25 sets planted in each of the three lines labelled II, III and IV. Sets for Nos. II and III were steeped in 1 per cent. copper sulphate solution for ten minutes. No. I was left untreated in any way as a control. All sets were selected from smut-free canes (Sanna-bile variety).

Plot No.	Treatment	Date of planting	Germination on 8-4-15	First appearance of smut on	No. of smutted shoots on		TOTAL
					31-8-15	12 2 16	
I	Control	13-3-15	53 shoots	2 6-15	1	1	2
II	Covered with spores; steeped.	13-3-15	28 ,,	12-6-15	1	25	26
III	Ditto	13 3-15	37 ,,	16-6-15	5	Over 500	Over 500
IV	Covered with spores; unsteeped.	13 3-15	58 ,,	16-6 15	1	Practically every shoot was smutted	

Remarks. There was no indication in the earlier stages of the experiment that adherent spores carry on the disease but towards the end[1] the infective power of adherent spores was quite clearly shown, practically every shoot showing the disease in plots III and IV and many in plot II. Steeping is again seen

[1] This result is in agreement with that obtained in Java as quoted by Dr. Butler (*loc. cit.*).

to have no value in the treatment of sugarcane smut, especially as it has again affected the germination of the eyes. The use of sets from healthy canes in the control plot gave a crop practically free from disease without steeping.

EXPERIMENT NO. 5.

1914.

This was designed to verify the deleterious effects of the copper sulphate treatment on the germination of sugarcane sets indicated in the other experiments.

Method. Sugarcane sets were steeped for different lengths of time and in different strengths of copper sulphate solutions (2 per cent. for 30 and 10 minutes; and 1 per cent. for 30 and 10 minutes). Sets with 100 eyes counted were used for each item and were planted on 22nd August 1914.

Observations on 16th September 1914 :—

Treatment	Number of shoots come up
2 % for 30 minutes	0
2 % ,, 10 ,,	1
1 % ,, 30 ,,	4
1 % ,, 10 ,,	9
Control—unsteeped	26

Remarks. Here, again, the deleterious effect of steeping is noticeable, though the germination even in the control plot was rather poor.

EXPERIMENT NO. 6.

1915.

This was carried out in the Seed-testing Laboratory at the Poona Agricultural College, to place beyond doubt the result of Experiment No. 5.

Method. Sets having 20 "eyes" in all were steeped in a solution of copper sulphate of 1 per cent. strength for ten minutes and another lot having 12 "eyes" on them were left untreated as control. These were germinated on moist sand. The experiment was started on 15th March 1915.

Results on the 26th March 1915:—

1.	Untreated	... All buds germinated; shoots vigorous, about eight inches, vigorous growth of adventitious roots.
2.	Treated	... Only three buds showing some life; hardly any root growth.

A photograph of this experiment taken on the 27th March is given opposite (Plate XX).

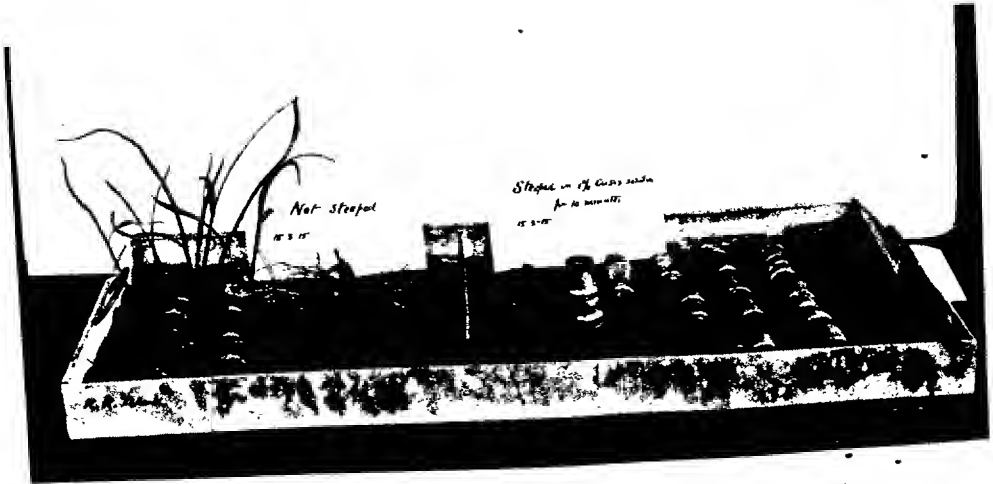
Remarks. This experiment leaves no doubt as to the injurious effect on sugarcane sets of steeping in copper sulphate solution.

General conclusions.

The above experiments indicate clearly that the surest way of getting smut in a crop of sugarcane is by the use of sets from diseased canes. The cultivators, as a rule, do avoid obviously diseased canes for planting purposes and this explains probably why the disease has existed so far only in the sporadic stage. As an additional precaution, however, it may be suggested that not only obviously diseased canes but also the whole of the stools which show the disease on one or more shoots should be avoided for seed purposes, as they are likely to contain the fungus though there may be no external signs of it.

That the source of infection when diseased sets are used for planting is the mycelium of the fungus in the tissues of the sets is indicated by the evidence obtained by microscopic examination of the tissues of affected canes. Even in hand sections, the mycelium of the fungus has been clearly made out in the sixth node behind the apex and it is possible it could be made out still further below by more elaborate histological methods. That the fungus can get into the buds and side shoots of an affected cane is also shown by the fact that side shoots of not more than six inches in length from quite near the base of an affected cane already show smut occasionally and further by the fact that microscopic examination in a few cases revealed the presence of the fungus in the tissues of the dormant buds of an affected cane.

Smut generally appears early in the life of the crop, in three to five months from the planting, when the source of infection is diseased sets.



Effect of steeping in copper sulphate solution on germination of sugarcane sets.
(Photograph taken on 27-3-15.)

Infection by spores adhering to sets takes place, but the attack in this case does not become obvious till the crop approaches maturity.

Aerial infection of shoots by spores and the formation of a dormant mycelium in them, is probable, though the above experiments give no direct proof of this. Infection by spores lying in the soil also possibly occurs. But these questions can only be settled by further study.

Steeping in copper sulphate solutions is useless and worse still, it affects injuriously the germination of sets.

The practical method of dealing with the disease suggested from the experiments is to destroy diseased canes whenever noticed and to avoid diseased stools for seed purposes. This alone may prevent the disease from going beyond the sporadic stage in which it exists at present.

THE TUBE-WELL AND ITS IRRIGATION POSSIBILITIES.*

BY

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THE climatic conditions prevailing in India, getting as we do, practically all our rainfall condensed into about 3 or 4 months of the year, with the remaining 8 or 9 months almost rainless, compel us to seek artificial means of watering the growing crops during the long dry period. We, therefore, rightly look upon the irrigation problem as an important one, and any methods of improvement in this direction will, I am sure, be welcomed by all who are in any way connected with the agricultural industry. We all of us then, in this meeting, start with a lively interest in the subject under discussion.

The tube-well is of many different sorts, but all have the same object in view, that of tapping the deeper and stronger springs of water. The kind we are mostly concerned with is of the strainer tube type, this being the most suitable for catching the percolation water in the deep sands underlying the whole Gangetic plain of this province. The ordinary pakka well is seldom sunk more than 30 feet beneath water level, and more often is only from 10 to 20 feet, so it does not always strike the copious springs of water in the lower strata. A hole is of course, frequently bored through the clay bed upon which a well-cylinder rests, thus getting the water from the first sand or water-bearing stratum beneath. In some cases, with exceptionally good conditions, such as a thick and strong clay bed above a thick stratum of coarse water-bearing sand, both being beneath subsoil water level, a very good yield of water

* A paper read at the United Provinces Co-operative Conference, held at Lucknow in February 1916.

is got, enabling a power pump to be used on the well, lifting as much as 8 or 10 *charsas*. Such places are exceptional though, and the great majority of wells in this province are giving two *charsas* of water or less. If at least a six *charsa* yield cannot be got from a well it does not pay to put in a pumping engine, the increased profit from the small area irrigated being insufficient to repay the initial cost of the plant and the running costs. This rule at once places most of the pakka wells of the provinces outside the useful limit for power pumps, unless they can be so improved as to cause them to yield a much larger quantity of water. We will consider later on in this paper the question of improvement of existing wells.

To return to the tube well. The difference then between it and the ordinary pakka well is that the former goes deeper, through successive beds of water-bearing sand, gathering the water from each bed, whilst the latter is shallow and draws its water from one sand bed only. The tube-well is generally sunk from 100 to 400 feet deep beneath ground level in this province. This may sound deep in comparison with the depth of ordinary pakka wells, but in reality it is not at all deep when compared with similar tubular wells in other parts of the world. In Australia, for instance, a lot of the borings are obliged to be from 2,000 to 4,000 feet deep in order to tap the underlying water, the strata above being all impervious to water and so being non-water bearing.

Although in this province we get, as I previously stated, practically all our rainfall in three months of the year, yet we are especially well favoured by nature with an inexhaustible supply of underground water, generally at a very moderate depth beneath ground level, to draw from to tide us over the dry nine mouths until the next rainy season. This underground water is stored up in the sand beds which extend to depths of thousands of feet beneath us, every cubic foot of sand containing roughly about one-third of a cubic foot of water. It will thus be seen what an immense supply of subterranean water we possess. It is not at all likely, so great is our supply reservoir, that any system of irrigation using more numerous and larger wells, can start to make an impression on our supply or even affect to any appreciable extent the subsoil

water-level. As long as our rainfall remains what it is, an average of over 40 inches a year for the province, our underground reservoir will be replenished annually and we need not fear drawing upon it to any extent necessary for irrigation. In a 40-inch rainfall something like 14 inches of water percolates through the upper strata down into our great natural reservoir and this is over the whole of the province. We lift for irrigation 6 or 8 inches depth of water for a *rabi* season and this only over about half the area of the province, say equivalent to 4 inches over the whole area. We thus see that far more water is annually put into our reservoir than we are ever likely to take out. It looks from these figures and statements, that the subsoil water-level would be constantly rising until we might suffer from a water-logged soil unsuitable for crops, but nature again comes to our assistance and provides a safety valve to let off the excess underground water, in the shape of numerous low valleys and river beds which act as great natural drains. Far more underground water drains off thus than we lift or ever will lift with extended systems of wells, for irrigation of crops.

Granting then our immense supply of water underground, we ought to study the question carefully as to whether we are making full use of this very excellent provision of nature, and when we compare the fine crops of canal-irrigated tracts with the poorer ones, and sometimes in the absence of winter rains the stunted ones, of some parts outside canal influence we are bound to confess, I am sure, that we are not doing all we should be in the way of water lifting. It is an extremely important matter, as only about one-fifth of the province is canal irrigated, leaving the other four-fifths to be watered by lifting from wells, *jhils* and *nadis*. There is no real reason why the crops of this province should not be as good and as paying in one part as another, whether within or without the area commanded by canals, were we to take full advantage of our underground store of water and employ modern methods of lifting it on to the land.

Areas irrigated from *jhils* and *nadis* are small in comparison with those watered from wells, so in this paper we will only consider the latter. What then is the best way of tackling the problem of

irrigation from wells? At present with the existing wells small areas of 8 to 15 bighas are watered round each good well, and in order to irrigate more extended areas we should either want a very large increase in the number of pakka wells or should require each existing well to give much more water. The tube-well comes in here as the great agent for well improvement where wells are suitable for it. By sinking a big tube-well in a good existing pakka well, it can be turned at once from a two *charsa* well into a 15 or 20 *charsa* one. The well should have a depth of water in it of at least 25 feet, to be suitable for taking tube-well, so a great many wells cannot be so treated. However, the tube-well is just as useful in yield, and costs no more, when sunk by itself as if it is sunk in an existing well. No matter how difficult the subsoil conditions are, the tube-well, if sunk, is master of the situation. In some places what is called a " mota " a thick clay bed is not found at all at reasonable depths, nothing but sand exists to rest the well-cylinder in, for an ordinary pakka well. Such wells in sand always cause trouble. The sand flows into the well, which requires frequent cleaning out, and often the brick well-cylinder sinks and cracks. At the best not more than one *charsa* of water can be got from such a well. A situation like this is especially favourable for a tube-well, and success can be absolutely relied on with it.

Again in other parts the clay beds are so thick and deep that a pakka well cannot get deep enough, at reasonable cost, to pierce them and strike the deeper water-bearing sands beneath, even though a hole be bored in the bottom of well. Here too the tube-well will succeed, as if need be, it can be carried down 200 or 300 feet until the coarse water-bearing sand is met with.

Regarding the cost of a tube-well, it varies according to the depth it has to be sunk. The boring must be continued until sufficient water-bearing sand is struck to give the requisite quantity of water. The cost is generally from Rs. 3,500 to Rs. 5,000. This may sound a high price when compared with that of a good pakka well costing perhaps Rs. 1,000, but compare the yield of water and it will then be seen that the tube-well is cheap. About 8 or 10 pakka wells at say Rs. 1,000 each would have to be sunk in order

to get as much water and irrigate as much land as one tube-well; so you get for Rs. 4,000 in tube-wells what you would have to pay Rs. 8,000 for in pakka wells. Further than this the price I mention for a tube-well includes a good engine and pump for lifting the water, and the use of a power pump will save the strain on bullocks at lifting water by *charsa*. The engine also can be used for other purposes besides pumping. For expressing the juice from the sugarcane a mill can be used, run from the engine, giving at least 10 times the outturn of the ordinary bullock mill. Or a small flour mill can be run and be made a source of profit. The area irrigated from one tube-well is about 8 or 10 pakka bighas a day or a total of 200 to 250 bighas in the season. The cost of the irrigation will of course vary with the depth from which the water has to be lifted. Taking 30 feet as the average depth from ground level to water level, at this depth the irrigation will cost about R. 1 per pakka bigha for each watering. Giving a *rabi* crop three good waterings during the *fasl* would thus cost a total of Rs. 3 per pakka bigha for the season, a cost which would be recovered several times over by increased crops due to proper irrigation.

Granted then that the tube-well is useful, and not costly for its output and utility, what is there to prevent its more extensive use? The main drawback is the very small holdings of the cultivators. A man cannot afford to put in a tube-well costing, say Rs. 4,000 which will irrigate easily 250 pakka bighas of land when he has only a few bighas of land himself to cultivate. The remedy for this is obviously co-operation, a number of men joining together to own a tube-well, and all getting water from the one tube-well in turn. This Conference is especially a co-operative one, and I would like to impress upon those present the very useful work that can be done by co-operative banks in sinking tube-wells. Success has hitherto been such that risk of failure may be regarded as negligible. There has been no single case of failure at all with our work in this province.

I am quite sure a tube-well is a sound investment and it is a form of well which I am certain has a big future before it in this province, the conditions being so eminently suitable.

AGRICULTURAL SAYINGS OF THE UNITED PROVINCES.

BY

V. N. MEHTA, B.A., I.C.S.,

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COLD weather touring is a great institution in these provinces and the officer who camps with his eyes and ears open will see and hear for himself in what a world of elemental hopes and fears the majority of the ryots move and have their being. They have the experience of untold centuries behind them and where this experience relates to agriculture they have for mnemonic reasons, set it to rhyme. These rough and ready rhymes escape their lips from time to time and when they hear you support your scientific explanations with an old world rhyme tried wisdom is imparted to it and it is accepted as gospel truth. On many a wintry evening have the old men of the village gathered round the camp of the present writer and talked to him about agricultural prospects. Agricultural rhymes have then accidentally fallen from their lips. The writer has collected these and others from *shagunbichar* books and privately owned manuscripts prescribing appropriate days for different agricultural operations. One Bhaddal Rishi is the general spokesman. Sometimes it is wisdom *à la Sahadeo* (the astrologer Pandava); sometimes it is the devoted wife nagging her patient husband to do something or forbear from doing something else.

In order that one may profit by this "wisdom"—full of empirical generalizations or occult pronouncements—a list of Indian Nakshatras or Lunar Mansions is given below with the names of the twelve signs of the Zodiac and it has been shown for Samwat 1972-73 for how many days each of these nakshatras lasted. The

months given are Indian months but their English equivalents which vary will be easily available. There are 12 rashis (signs of Zodiac) which are divided into 27 divisions called nakshatras, each rashi containing $2\frac{1}{4}$ nakshatras.

Most of the sayings turn on rain—its normal fall or defect or excess. The first monsoon nakshatra is Mrigshar and commences from the Badi 10th of Jeth, 1972.

Indian Nakshatras or Lunar Mansions.

Constellation	Date on which the constellation begins	Sign of Zodiac	Date on which the sun enters the sign of Zodiac
* (5) Mrigshar (½) * (6) Ardra .. * (7) Punarvas (¾) ..	Jeth Badi 10, 1972 ... Jeth Sudi 9 ... Asarh Badi 9	Mithun or Gemini.	June 14th.
Do. (¼) * (8) Pushya ... * (9) Ashlesha	... Asharh Sudi 7 .. Sawan Badi 8 ..	Kark or Cancer.	July 16th.
* (10) Magha .. ... * (11) Purva Phalguni ... * (12) Uttra Phalguni (¼) .	Sawan Sudi 7 .. Bhadon Badi 6 ... Bhadon Sudi 4 ...	Sinh or Leo.	August 17th.
Do. (¾) ... * (13) Hasta *alias* Hatnia . * (14) Chitra (½)	.. Kuar Badi 4 .. Kuar Sudi 2 ...	Kanya or Virgo	September 17th.
Do. (½) .. .. * (15) Swati .. ... (16) Vishakha (¾) ..	.. ... Katik Badi 2 ... Katik Badi 14 ..	Tula or Libra.	October 17th.
Do. (¼) ... (17) Anuradha ... .. (18) Jyeshtha . ..	... . Katik Sudi 13 ... Aghan Badi 10 ...	Vrishchak or Scorpio.	November 16th.
(19) Mul . (20) Purva Asharh ... (21) Uttra Asharh (¼) ...	Aghan Sudi 9 ... Pus Badi 7 ... Pus Sudi 6 ...	Dhan or Sagittarius.	December 15th.
Do. (¾) .. (22) Shrawan . ... (23) Dhanishta (½) ...	...... Magh Badi 3 ... Magh Sudi 3 ...	Makar or Capricorn.	January 14th.
Do. (½) ... (24) Shatatarka ... (25) Purva Bhadrapad (¾) ...	..... Magh Sudi 15 . Phagun Badi 14 ..	Kumbh or Aquarius.	February 12th.
Do. (¼) .. (26) Uttra Bhadrapad .. (27) Revti	..... Phagun Sudi 12 . Chait Badi 12 .	Min or Pisces.	March 13th.
(1) Ashwini ... ... (2) Bharni . ... (3) Krittika (¼) ...	Chait Sudi 9, 1973 ... Bysakh Badi 9 ... Bysakh Sudi 8 ...	Mesh or Aries.	April 12th.
Do. (¾) .. (4) Rohini ... .. (5) Mrigshar (½) ...	... Jeth Badi 8 .. Jeth Sudi 6 ...	Vrishabh or Taurus.	May 13th.

* Rain nakshatras.

N. B.—The number within the brackets indicates the chronological order of nakshatras.

The moon in the Puranas is represented as courting the 27 daughters of Daksha Prajapati for 14 days each. These nakshatras are the wives of the moon. It is also believed that they represent the ethereal bodies of pious persons after death and therefore they are expected to influence the affairs of men here below. The moon is the lord of aushadhis or plants and hence his journeys in the firmament are watched with special interest by the agriculturists.

The seven days of the week are presided over by the following planets :—

Sunday	Sun	Surya.
Monday	Moon	Chandra.
Tuesday	Mars	Mangal.
Wednesday	Mercury	Budha.
Thursday	Jupiter	Brihaspati.
Friday	Venus	Shukra.
Saturday	Saturn	Shanishchara

For the sake of easy reference these sayings have been abstracted here under three main heads.

(1) Rain prognostications.

(2) Agricultural operations, crop diseases, etc.

(3) General.

I. Rain Prognostications.

(a) *Interdependence between weather conditions in winter and summer on the one hand and rainy weather on the other.*

If on Katik Sudi 11th clouds and lightning are seen in the sky then there will be good rain in Asharh.

The appearance of clouds and lightning on Katik Sudi 15th with Krittika as the nakshatra foretells four months of good rainfall.

Katik Amawasya falling on Saturday or Sunday or Thursday in the Swati nakshatra is an omen of approaching famine

Rain on the 8th day of Aghan is a good omen indicating copious rainfall during the whole of Sawan.

If the 7th of Pus goes without rain then during the Ardra nakshatra the sky and the earth will be one with rain.

If the Pus Badi 7th is without clouds or rain Sawan Sudi Punam will be a rainy day.

Lightning seen on the 10th of Pus is a happy sign of coming rain during the whole of Bhadon.

If it rains on the 10th of Pus Badi it is predicted that there will be a good rainy season.

If clouds are seen on all sides on the 13th of Pus Badi then Sawany Punam will be rainy.

If all the four directions are full of wind on Pus Amawasya, you must thatch your cottage well there will be plenty of rainfall.

The price of grain will be twice, thrice or four times dearer according as Pus Amawasya falls on Saturday, Sunday or Tuesday; if it falls on Monday, Friday or Thursday every house will be resonant with dulcet strains. (There will be plenty of grain.)

If on Magh Pariwa (bright half) clouds are seen on the horizon and the wind is blowing then Til (*Sesamum indicum*) and Sarson (*Brassica campestris*) will become dear.

Thunder and lightning on Magh Sudi 3rd is a sure sign that barley and gram seeds will be dear. If clouds are seen or if it rains on the 4th then *pan* and cocoanut will be dear.

Thunder on the Magh Sudi 7th, Pus Sudi 5th and the 10th of Aghan indicates that there will be four months of good rainfall.

The gentle wife speaks to the husband:—"If Magh Badi 7th is cloudy and lightning be seen, don't be moody, there will be good rainfall." (This the present writer thinks refers to winter rains or Mahawat and not to the good monsoon rains).

If the sky is of emerald green on Magh Purnmasi there will be seasonable rainfall. One female friend says to another "if no dew is seen on that day grain will be dear."

It is predicted from bright and clear sky in the month of Magh with Jyestha as nakshatra that all the seven staple kharif crops will be produced.

[The seven Kharif crops are:—

Kuri (early rice).
Kakuni (*Setaria italica*).
Mandua (*Elusine coracana*).
Sama (*Panicum frumentaceum*).
Makai (*Zea Mays*).
Kodon (*Paspalum scrobiculatum*)
Dhan (*Oryza sativa*)]

If on Phagun Sudi 2nd there be neither cloud nor lightning it will rain well in Sawan and Bhadon and you will enjoy Tij (Kajri Tij in Bhadon is a gala day for women).

Cattle suffer if Phagun Amavas falls on Tuesday.

If Phagun has 5 Tuesdays and Pus 5 Saturdays then alas for you, do not even sow your seeds.

If it is blowing from the west on the Holi day the whole earth will blossom forth; if from the east then the rainfall will be erratic, if from the south all the seven grasses will grow seasonably; if from the north there is sure to be good rain: if the wind is blowing from all the four sides then the ryots will suffer.

If there is severe dust storm (*rak* or ashes) on the 8th of Chait and if the 9th is wet and lightning appears there will be severe famine. The appearance of clouds and lightning on the 10th will be followed by failure of rain; but if the 10th is rainless the monsoon rains will be plentiful.

If seeds are wetted in Chait, and the petals of the beautiful *Butea frondosa* (Dhak) are washed in Bysakh and the sun shines at its hottest in Jeth, they forecast good rainfall.

Whatever be the length in Gharis of Chait Amawasya that will be the measure of the sale of unhusked rice in Katik.

If Revti is wet there will be no rains.

If Ashwini is wet there will be deficiency of rain towards the end of the season.

If on the 1st of Bysakh there are clouds and lightning then you can get very little value in exchange for 20 Jaipuris (old Asharfis).

Bysakh 3rd falling on Thursday augurs well for crops.

Wet Bharni is a bad sign, it will destroy even grasses.

If on the 5th the wind is blowing from the north then Bhadon will be a dry month. If no thunder is heard on the 6th then cotton will be dear. If the 7th ends cloudless there will be no rain on earth and no hope will be left. Ghee and oil will be twice as dear if the 8th falls on

Monday. If on the 7th there are clouds and rain there will be much rain in Asharh. If the 7th sees lightning, clouds and dewy precipitation, then all the four months will rain well. If the 7th is cloudless and 8th cloudy, Asharh (the principal rain month) will be dusty. Even big lakes will dry up if the 9th is cloudless and there will be no rain. If there is a Mandal or watery halo round the moon on the 9th move away your cottage, don't trust.

Wet Krittika is a precursor of plentiful fall at the end.

If Krittika rains grain will be dear, if Mrigshar rains then there will be bumper crops but if Rohini weeps then direst famine will follow.

If Krittika is dry and Ardra does not rain a drop Bhaddari is croaking and declares "you know very well that havoc will be wrought by famine." This is just the time for sowing Kharif crops and unless the means of irrigation are at hand absence of rain at that time is fatal.

The Moon has 27 companions but if only Krittika sprinkles the earth, everything is all right. If there be no wind during Mrigshar and Rohini constellations, if Jyeshtha does not bake (people) all round, then the fair lady (Gouri) will have to stay out on roads picking ballast stone.

Rohini nakshatra falling on Badi 10th prognosticates that there will be little rain and little grain ; if that day is cloudy and it thunders "you, dear, go to Malwa" says the lady "and I to Gujerat." (Malwa in Central India and Gujerat in Western India are in popular imagination proof against famines.)

For winter rains it is said that if clouds come on Friday and stay on on Saturday then Bhaddar Rishi declares infallibly that they will not go away without raining.

It is not easy to say what the Bay or the S. W. Monsoon Current has to do with the N. W. Current well established in Upper India. But one has to live and learn and ultimately some connection will be established between the monsoon and winter rainfall.

(b) *Rain during the four months of rainfall and its effects on crops.*

If Jeth Parewa is hot and the 2nd thunders there is no doubt that the year will be a good one.

If Jeth Badi 10th falls on Saturday there will be no water on the earth.

Famine will follow if it rains on Jeth Sudi 3rd and the constellation happens to be Ardra.

If Rohini is wet and Ardra is windy then sell off your bullocks, there will be no profits in cultivation.

If Ardra is not rainy and Mrigshar is without wind Bhaddari declares that there will not be a drop of rain.

If the beginning of Ardra is rainy and Hast is wet at its tail then whatever tax the king may exact from the tenants the cultivating householders will be happy to pay. [The reason is simple. Early Ardra rains are required for rice and tail Hast rains for maturing kharif crops and preparing fields for rabi.]

East wind blowing in Jeth is a precursor of dust storms in Sawan.

If the month of Magh is hot while Jeth is cold and if tanks are filled up by the first rains then the poet Ghagh declares "Better be an ascetic (times will be hard for agriculturists while the ascetic will get his bread anyhow) because Dhobis will have to wash clothes in water drawn from the wells (rivers and tanks will be dry).

If Asharh Badi 5th is cloudless the dear one must go to Malwa to beg for bread.

The Bhaddar 9th (Asharh Badi 9th) falling on a Saturday is such a bad omen of impending famine that not a soul will outlive that year.

The Asharhi Punam has thundered and all the seven kharif crops will mature. If even the tip of the temple banner is wetted that day by rain there will be good times all round.

If the wind is coming from north-east on Asharhi Punam then, oh cultivator, sow your crops on uplands. (There will be plenty of water to inundate low cultivation.)

If the moon rises cloudless on Asharh Punam, you dearest go to Malwa, there will be acute distress here.

The wind blowing on the evening of Asharhi Punam in the middle of the sky or from the east, north or north-east is good. That from south-east, south-west or north-west is very bad.

The astrologer declares "Why are you cast down? Asharhi Punam has thundered and all the seven kharif crops will grow."

If Chitra, Swati and Vishakha rain in Asharh then husbands must go to another country, oh friend, for there will be a very severe famine.

If Pushya and Punarvas did not fill the tanks then expect rain next Asharh.

If the sun rises cloud-covered on Sawan Badi 5th, then move off your hut from the bank of the river.

If on Sawan Badi 5th it is blowing, then there will be a famine and birds in anticipation migrate to other countries.

If on the midnight of Sawan Sudi 7th there is thunder, then you dearest go to Malwa, I shall go to Gujerat.

If Chitra, Swati and Vishakha of Sawan do not rain down, garner grain; it will be worth twice as much.

Just as a child is not satisfied till the mother has served up the food so the soil is never satiated unless it rains in Magha. The Uttra has given her answer (in the negative) and Magha kept her maw shut, times were bad and Chitra gave reply and the situation was saved. (This is for rabi sowings.)

He who says that there will be rain in Magha, why he will see fruits on all plants.

Magha is proclaiming at every field boundary her influence and big and small, all rice stalks bear ears.

If on the Amawas of Bhadon a rainbow is seen in the west, there is the cry of 'alas.'

The east wind blowing in Bhadon will make rivers happy and boatmen ply their trade.

If east winds blow during Purva nakshatra, then even in dry river channels you will ply boats.

It is bad for Purva to be rainy.

It is said "He who says that Purva will rain down all the crops will be eaten by worms."

If it rains well in Uttra there will be such a bumper crop that even dogs will not eat the superfluous outturn. [In the western districts it is not necessary to have much rain after Uttra. Kharif crops have already matured and rabi soil is cooled down. However where there is transplanted rice Hast rains are wanted.]

Oh rice—you get hands and feet in Hast, in Chitra you get flowers and when Swati is coming on, you are spreading like a flowing robe. If Magha rains well, nothing more is desired. If not then you might wring your hands.

If Hast is rainy then wheat will grow up to the chest. [Hast rains cool the soil and if the moisture is well conserved by good tillage and producing a mulch at the top wheat will grow even without much subsequent irrigation.]

The elephant (play on the word Hast) has wagged his tail and the Jowari crop has been ripened without any more ado. (This especially refers to parts where September rains are most prized for maturing the kharif crops and cooling the ground for winter sowings.)

If it rains in Hast three crops prosper, Rice (Shali), Sugarcane and Urid (*Phaseolus radiatus*). If it rains hard in Hast three crops are ruined—Til, Kodon and Kapas.

If it rains in Chait three crops are spoilt, mothi, pulse (Urid), and sugarcane.

If there is rain in Swati and Vishakha neither will there be spinning nor will the music of cotton carding be heard.

A small fall in Swati (not a heavy and continuous downpour, otherwise cotton and dry kharifs will be ruined) is so beneficent that Kurmis (cultivators) will put on golden bangles.

If it rains in the middle of Pus the wheat plant will yield half its weight of grain and half its weight of straw. It will be a splendid crop.

Without Tula (sun entering Libra) rice ears will not appear.

If the eastern wind blows without ceasing and the widow puts on ornaments, as sure as anything, there will be rain and she will lead people astray.

Thunder in the south-west promises an early rainfall.

Rainfall will be plentiful if there is lightning towards Kampilya. (This proverb is of Etawah District.)

Partridge-coloured clouds with collyrium-like streaks on them indicate that there will be good rainfall.

If gusts of wind come like a hopping partridge then Bhaddari declares there will be good rainfall.

Good rainfall is also predicted if water gets warm by keeping, birds wallow in dust, and if ants migrate with their eggs.

If the moon is cloudy and the day is hot with sun and the eve bright with stars believe them as sure signs of famine.

If clouds start coming on Friday and bank upon Saturday there will surely be rain.

Crows cawing at night and jackals howling by day prognosticate that there will certainly be famine.

Rains when cotton is nearly ripe ruin the crop.

If the wind blows properly from south-west then you will get plenty of water at home. [This south-west wind is also called Bamura and Banda.]

If clouds overtake clouds on the horizon then Bhaddari declares that rain is imminent.

The howling of jackals during the day and the flowering of *kans* weed give no hope of rain. (*Kans* is flooded out and killed by good rainfall before it flowers.)

The Moharram which is associated in popular mind with burying of the old and the resurrection of fresh life' has interwoven its importance into the lives of cultivators, be they Hindus or Musalmans, and therefore the fall of the 3rd of Moharram on any particular day of the week is carefully watched to draw omens from.

If the 3rd falls on Sunday, then there will be good rainfall, grain cheap and bumper crop of sarson (*Brassica campestris*). Trees will bear many fruits, wheat will be good, sesamum and grass plentiful and milch animals will prosper. Only cotton will be poor. But if the 3rd falls on Monday there will be half the normal rainfall. Grain will, however, be cheap, sesamum and cotton good and sugarcane plentiful. If it falls on Tuesday it will bring on unseasonable rainfall and famine. Fruits will be blown off unripe. Sesamum, sugarcane and cotton will be scarce. Servants will leave their masters and parents their children. Locusts will come. If the 3rd of Moharram falls on Wednesday, Til, Gehun (wheat) and Ganna (sugarcane) will be dear, but there will be plentiful melons and locusts. The same event coming on Thursday will give plentiful rains with good crops but the winter will be very cold. If it comes on Friday, grain will be cheap, there will be plenty of milk and a bumper crop of wheat. If the 3rd falls on Saturday, cattle will die in great numbers. [These prognostications about weather are given out by one Fateh Ali Bhaddari of Azamgarh District.]

(To be continued.)

NOTES.

Mixed crops. The Indian custom of growing gram and wheat together as a mixed crop is well known and has often been described in the literature. The practice is particularly common on the black soils of Peninsular India and also in the tract comprised by the Western Districts of the United Provinces and the Eastern Punjab. The advantage in mixing the crops is generally considered to be the insurance obtained against an entire failure of the harvest in years of short moisture. Under such conditions, the deep tap root of gram is supposed to reach the lower layers of the subsoil and to abstract moisture therefrom.

The mixture, however, has another advantage and this is concerned with the nitrogen supply. On the black soils of the Peninsula, it is exceedingly probable that denitrification is common during the monsoon phase, and that the amount of available nitrogen is small at the time when the *rabi* crops are sown. In November and December, the wheat crop in this region looks very thin and pale, and the foliage is wanting in that robust appearance characteristic of wheat grown on land moderately rich in available nitrogen. If the supply of nitrogen is limited, it would obviously be a great advantage to the wheat to be grown mixed with a crop like gram which is able to make use of atmospheric nitrogen and so relieve the pressure on the combined nitrogen. A similar state of affairs exists in Northern India. The marked response of wheat to organic manures on the somewhat sandy loams of North-West India, where wheat and gram are grown together, indicates that here too it would be an advantage to limit competition for the nitrates dissolved in the soil water.

An interesting confirmation of these ideas has just been obtained in the Botanical Area at Pusa. Of late years, a number of new wheat crosses have been worked out between Indian types of high

grain quality and rust-resistant, strong-strawed English kinds. The work is now in the sixth generation and new rust-resistant forms have been fixed with exceedingly strong straw and vigorous rooting power. These withstand wind, retain their erect habit up to ripening time, and stand out in strong contrast to ordinary Indian types which always lean away from the prevailing wind. The single plants of these crosses were sown as usual grain by grain in October 1915 in small plots of three lines each and the cultures were separated from each other by a line of gram. The field was therefore a mixed crop of wheat and gram in the proportion of three of wheat to one of gram, a mixture, as regards the relative amounts of the two constituents, not unlike that often met with in practice.

As the wheat ripened, a curious phenomenon disclosed itself all over the culture field. The outer lines of wheat of each plot next to the gram were distinctly taller than the middle line and appeared to be more vigorous. These lines were growing in soil next to the gram and therefore would be expected to obtain more nitrogen than the central line of each wheat plot. At harvest time, weighings were made of the seed of 20 plants taken from the middle line of plots and from the corresponding outer line next to the gram. The first of these plots was about the centre of the field where the soil was not very fertile. The second was towards the southern end of the culture field where the natural fertility was considerably greater, due to accumulations of silt formed by the natural terracing of the field. Care was taken to select representative samples of the whole. The results were as follows, the weight of the seed of 20 plants being expressed in grammes:

	Row next to gram	Inside row	Percentage increase
1	178·4	108·5	65
2	302·0	241·2	25
Total	480·4	349·7	Average 45

The total difference in favour of the wheat next to the gram is therefore 130·7 grammes and the average increase is 45 per cent.

Weighings were next taken of the grain of the whole of the outer and inner lines of two cultures from the southern end of the field. The results, in grammes, are given in the next table :—

	Outer row	Inner row	Outer row
1	594	470	635
2	661	548	621
Total	1,255	1,018	1,256

In the first case, the average increase of the outer lines above the middle line is 145 grammes or 30 per cent. In the second case, taken from the most fertile corner of the culture field, the average increase is less, namely, 93 grammes, or 17 per cent. It will be observed that, in all cases where the soil, judged by the vigour of the wheat crop, was richest, the difference between the yield of the inner and outer rows is less. This fact supports the explanation that these differences are due to the nitrogen supply of the wheat. Taking all four determinations together, the average increase in grain production of the lines next the gram is 34 per cent. above that of the middle line of each plot. The figures indicate quite clearly that there is a marked advantage in growing mixed crops of gram and wheat on soils where combined nitrogen is a limiting factor.—[A. HOWARD].

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The effect of Sulphur on crops. Attention was drawn in April 1914 in a note in Vol. IX, Part 2 of this Journal, to certain observations on the effect of sulphur on crops, and it was suggested that it would be worth while testing the effect of sulphur on soils where it had not been previously tried.

In 1915 such tests were made on the Ranchi Farm, quantities of sulphur from 10 to 40 lb. and gypsum containing some 30 lb. of sulphur per acre, being severally applied to a large number of plots of groundnut.

The effect was in every case very remarkable, the gypsum producing an average increase of 8 maunds per acre of groundnut,

and the plots to which sulphur or gypsum was applied being very much more luxuriant than the control plots.

As far as could be judged by appearances, 10 lb. of sulphur per acre produced as much effect as 40 lb., but the larger quantities gave slightly larger yields of nuts.

Twenty pounds of sulphur per acre applied to rape also produced a remarkable effect, the crop being very much more luxuriant and continuing to flower for quite a fortnight longer where the sulphur was applied.

In a paper in the *Journal of Agricultural Research* (Vol. V, No. 16, of January 17th, 1916) Walter Pitz, Assistant Agricultural Chemist of the Agricultural Experiment Station of the University, Wisconsin, shows by pot experiments with two soils, that small quantities of calcium sulphate may increase the growth of legume bacteria and the yield of red clover—an increase which is accompanied by a greater root development and an increase in the number of nodules. The smallest proportion of calcium sulphate used in his experiments would, however, even if calculated only on the top 4 inches of soil, connote an application of more than five times the largest quantity used per acre in the experiments at Ranchi: and it would seem probable that, in laboratory experiments with sulphur, increments of the order of 0·001 per cent. of the weight of soil would give more useful results than increments of ten times that magnitude.

The *Monthly Bulletin of Agricultural Intelligence and Plant Diseases* for December 1915, contains (p. 1,629) an abstract of a paper by F. C. Rimes, Superintendent of the Southern Oregon Experiment Station, on the effect of sulphur on alfalfa at that Station.

Many references are also given to previous papers on this subject.—[A. C. Dobbs].

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An interesting note by Mr. Barnes, Agricultural Chemist, Punjab, has been received dealing with the **mineral constituents of cotton lint**. It arose from the supposed adulteration of raw Chiniot cotton, by the addition of earth salts to increase the hygroscopic

properties and the investigation of such a possibility led to the discovery that the inorganic constituents of this cotton fibre were far more variable than had hitherto been supposed and the large percentage of magnesium chloride it contains seems likely to seriously affect the reaction of the fibre to dyes.

We quote Mr. Barnes' summary *in extenso* as it points to another factor which will have to be considered by the grower, breeder, and buyer.

"There appears to be no evidence of the reported practice of salting the cotton to increase its water holding capacity. Mr. Arno Schmidt reports that he has seen watering of raw cotton actually taking place, but this is a crude form of sophistication and will certainly lead to deterioration of the fibre and cannot but come to the notice of the buying agents of exporting firms in India. It will thus rebound immediately on the persons practising this fraud and can be dismissed from the scope of this enquiry.

"The complaint of Messrs. Volkart that the Chiniot cotton contains an unusually high percentage of magnesium chloride seems to be true, but we do not think that this substance has been artificially added, for the analysis of sample No. 53 shows that it compares with other genuine samples in the amount of water and mineral matter which it contains. The assumption that cottons grown on saline soils will produce a fibre more heavily impregnated with mineral matter does not seem to be justified by the results, for alkaline soils are much more prevalent in the Punjab than in Bombay.

"The total amount of ash material in cotton fibre seems to have been under-estimated by previous workers who seem to have assumed that this was largely due to foreign mineral matter in the form of dirt in the baled cotton.

"The presence of highly varying quantities of silica especially seems to have escaped attention. I am inclined to lay considerable stress on the established fact that genuine cotton fibre may contain upwards of one per cent. of ash, and that the composition of this ash is variable and variable to a far greater extent than has hitherto been supposed.

"There is little doubt but that this will seriously affect the reaction of the fibre to dyes—how far it will affect the tensile strength and keeping qualities of the fibre remains to be shown. It is evidently a factor which both grower and breeder must take into consideration, namely, the nature and quality of the mineral salts taken up by different varieties of cotton grown in the same soil, and under the same conditions, and how far climatic variation will effect this, as well as the effect of these mineral constituents on the commercial value of the fibre."

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Abortion Bacillus. The remarkable discovery of G. C. Schroeder and W. E. Cotton on the persistence of the abortion bacillus in the milk of cows, and particularly the demonstration of the fact that in one case it was eliminated from a cow's milk for four and a quarter years, is a most interesting contribution to what was already known concerning the bacillus. As far as our preliminary investigations have gone in this direction, we find that the bacillus is present in the milk of cows in the herds we are using for our work, and this milk injected into healthy guinea-pigs does produce pathological lesions and death.

We collected in November last year a number of samples of milk from cows which were known to have aborted. Utmost regard was given to asepsis in order to eliminate all possibilities of extraneous contamination. Sterile tubes were filled by squirting the milk therein from some distance. With this milk guinea-pigs were inoculated intraperitoneally with quantities from 5 to 15 cc.

Before injecting the milk was warmed to prevent shock. We find that guinea-pigs can accommodate large quantities of milk without any discomfort. Workers in this laboratory have used as high as 30 cc. without untoward results.

The first guinea-pig died on the thirty-sixth day following the infection, the second on the forty-fifth day, and several between this later period and the fifty-sixth day. *Post-mortem* examinations of these pigs revealed the characteristic enlargement of the spleen. The lymphatic glands presented signs of degeneration. The liver

was enlarged, with whitish spots throughout its substance. In some of our guinea-pigs the characteristic changes in the organs were not so pronounced as recorded by Schroeder and Cotton, but this may have been due to the cold quarters reducing the vitality of the small animals, so that they died before any great degenerative changes had taken place. Further, our organism may be of a greater virulence. In all our autopsies the clinical lesion in the spleen was taken as suggestive of infection, and it was from this organ that our cultures of abortion were obtained. Spleen pulp spread over the surface of the solid tube media gave excellent growths in reduced oxygen. The bacillus obtained in these cultures possessed more rapid growing qualities than those obtained from material in the original host (the placenta and uterine contents).—*Report of Veterinary Director-General, Canada.*

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Root Pruning. This operation is performed in the case of those fruit trees which make a free growth, but produce little or no fruit. This operation also requires skill and experience. To do this properly, dig a trench in winter 3 feet deep around the tree and about six feet away from the main stem. Any root met with while digging the trench should be cut back to its inner side. If only few roots are met with at the above-named distance from the main stem, then dig gradually closer to the latter all around until you reach a point where root growth is profuse. Then cut off all the main roots to be seen with a sharp knife. When this has been done, mix the turned out soil with one or two dozen baskets of manure and return it to where it was taken from.—*The Fruit Garden in India.*

REVIEWS.

The Milk Problem in Indian Cities. By LEMUEL L. JOSHI, B.Sc., M.D., Municipal Analyst, Bombay. Published by Messrs. D. B. Taraporevala Sons & Co., Bombay. Price Rs. 5.

IT cannot be said that this work is an addition to the literature on the question of milk supply in the East as it really is the beginning of reliable written records and conclusions on the all-important subject of the milk supply to Indian urban communities. Dr. Joshi has a wide experience of the subject from the public health point of view, and although to some extent he deals with the technical or dairying side of the question the book cannot be regarded as a work on dairy technology, but rather as a lead for the educated public in general, and those engaged in safeguarding public health in particular, on the milk question in cities.

The picture which Dr. Joshi draws of the present condition of the dairy industry in India corroborates the findings of the Board of Agriculture at their Coimbatore meeting, and in no way does the author overstate the case here. After reviewing the present conditions of city milk supply, Dr. Joshi goes on to describe what he considers to be the reasons for the existing deplorable condition, and then he suggests certain remedies. The conclusions drawn as to the cause of the existing state of affairs are sound generally, and Dr. Joshi classifies remedial measures under three heads :—

(1) Economic, educational, and general measures.
(2) Sanitary measures.
(3) Legislative control.

In connection with (1) the author materially gives prominence of place to the breeding, rearing, and tending of a dual purpose

cow for India, or in other words, a breed of ox of which the males will be suitable for draught and the females for milk production.

The question of improved feeding, housing, and general care of the animal is fairly fully dealt with, and the difficult problem of the organization of cow-owners for the purpose of selling their produce and generally applying modern business methods to the industry is discussed. Co-operation is recommended as a means of solving this end of the problem, and it is a pity that Dr. Joshi did not give us more details as to how such co-operation might be applied in India. Throughout the work he quotes freely what has been done in other countries, and he might well have given more particulars of how co-operative methods have been applied to the needs of the dairy industry, especially city milk supply, in Europe and the Colonies. Not only so but the knowledge and experience Dr. Joshi exhibits throughout this work would well enable him to enlighten us as to how foreign co-operative propaganda could specially be applied to Indian conditions. Various measures to be undertaken by the State in the direction of educating the cow-owners and the public are discussed, and the author's suggestions here generally follow the lines of the recommendations of the Board of Agriculture.

Dr. Joshi rightly believes that the economic, sanitary, and other measures advocated should take precedence of legislative action, but he regards the latter as a necessary corollary of dairy educative propaganda. His recommendations as to the fixing of standards of quality are in the main sound, and the difficulties of differentiating between cows' and buffaloes' milk and fixing standards applicable to both are dealt with. The question of estimating the cleanliness of milk by its bacterial contents is very fully discussed, but although the author is cautious in his recommendations as to fixing standards of bacterial contents, here the practical dairy expert will not follow him, until it is more clearly established that the figures given as quantities of germs present in given quantities of milk are really what they represent, and until this fact can be readily demonstrated to the ordinary well trained dairy manager.

On the whole, the work is a sound treatise on an all-important subject, and the conclusions drawn by Dr. Joshi might with slight modifications be taken as the basis of dairy reform here.—[W. S.]

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Well Waters from the Trap Area of Western India. By HAROLD H. MANN, D.Sc., Principal, Agricultural College, Poona (Department of Agriculture, Bombay. Bulletin No. 74 of 1915). Price As. 6 or 7*d*.

INDIA is at times visited by severe droughts which affect considerable tracts of country, and cause much distress to the agricultural population. Government tries to render the work of the cultivator as far as possible independent of the variations of the season by the provision of suitable irrigation facilities. By anicuts and canals fullest advantage is taken of the waters in many of the great rivers. Irrigation from wells is also made use of to a considerable extent and has the advantage of being cheap enough to be within the means of the cultivator.

In Western India, except for a comparatively small area, served by canals and tanks, almost the whole of the irrigation is conducted from wells. The total number of wells is enormous and they are a very important factor in the agriculture of the country.

The problems presented by well-irrigation are hence worth a closer investigation in their chemical, geological and engineering aspects than they have received in the past. Dr. Mann's paper is therefore very welcome.

In the trap area, the water in a well is almost always what may be termed "fissure water," that is to say, it is not a generalized subsoil water which is tapped, but water flowing in definite fissures in a definite direction. In digging a well one has to take his chance of meeting a fissure containing flowing water. This makes any attempt at digging an ordinary well by tube boring or by any other means of digging a *narrow* trial hole, of very uncertain value, unless the presence of water has been made fairly certain beforehand.

The above is, of course, the general case. But there are a considerable number of enclosed valleys even in the typical trap area where there is a generalized underground water supply over a limited area.

Analyses of typical well waters are given by Dr. Mann. Attention is drawn to the fact that the application of certain well waters makes the soil very impervious to water and hence very hard and difficult to wet. In such cases the waters contain a large quantity of alkaline bicarbonate and a small quantity of other sodium and potassium salts. If chlorides or sulphates in larger quantity accompany these alkaline bicarbonates, they are relatively innocuous; but if the bicarbonates of the alkalies are present in quantity greater than the chlorides, they are injurious. The actual effect seems to be a destruction of the tilth of the soil owing to a deflocculation of the colloid clay material so that on mixing with water the solid matter remains suspended for practically an indefinite period.

As to the amount of dissolved salt in the water which will render samples of water unsuitable for irrigation, it has been found that, so long as these do not contain a large excess of alkaline carbonate or bicarbonates in excess of the amount of lime salts and of the chlorides and sulphate, well waters are useful for irrigation until the amount of salt reaches 200 parts in 100,000 (or 0·2 per cent.)

At Dhulia a systematic study has been carried out to ascertain to what extent the character and quantity of salts vary at different times of the year in the same well. The extraordinary constancy in the composition shows that the water which is drawn up from rock fissures in wells like that at Dhulia is not surface water, but represents the tapping of a very considerable underground water reservoir. This might have been also concluded from the fact that the supply, though diminishing in the hot months, never ceases.

An examination of the waters of some wells near Surat proved the interesting fact that in this part there is not a general reservoir of subsoil water. The water differs in composition and depth in different wells within a short distance from one another. When

a well is emptied the water usually flows into it chiefly, if not entirely, from the eastern side.

Nearly all the wells in this part of Gujarat are somewhat salt due to a continual seepage from the sea. During the famine years (1896 and 1900) the sources from which the wells in Gujarat are usually supplied were dried up and many of the wells gradually became salt. Many have remained so, and useless ever since; others have gradually after several years become sweet again. This can only be the result, it seems, of sea water coming in, when the fresh water current from the East, which usually kept it back, failed. The effect of short rainfall in Gujarat on the character of the water in the wells is thus serious and the permanent effect of a long drought may not be limited to its action on cattle and men. It follows also that there is much danger in utilizing too great a proportion of the water available in such wells, and the haphazard use of well water for irrigation purposes ought to be put a stop to.

The author is to be congratulated on this excellent work and the results of his further studies will be awaited with considerable interest.—[J. S.]

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A Soil Survey of the Guntur Delta. By W. H. HARRISON, M.Sc., and B. VISWANATH, Bulletin No. 70, Department of Agriculture, Madras. Price R. 1-8 or 2*s*. 6*d*.

THE importance of a systematic study of the field differences in soil is recognized by all interested in agricultural work. Not only is the result of the soil survey of a locality of great help to the practical farmer, but it also is of use to a wider public in as much as it furnishes an important factor for the determination of land values.

Dr. Harrison and his assistant have just published a second instalment of the result of their survey of the Madras soils, the first referring to the soils of the Tanjore delta (Bull. 68). The present work deals with that portion of the delta of the Kistna river which lies in the Guntur district and is under the Kistna irrigation project. 111 samples of soil were collected from typical fields whose recent

manurial history could be obtained and which are under paddy cultivation.

The results of the analysis, which consists of the estimation of lime, magnesia, nitrogen and total and available potash and phosphoric acid, are entered in a table and also shown graphically in maps of which there are many.

A study of these maps is very instructive and serves as a guide to the manurial requirements in different areas.

It is seen that the nitrogen content of the delta soils is low and the introduction of special manurial methods with the object of rectifying this would lead to great benefit. It is further seen that the effect of the river silt profoundly modifies the manurial character of the soil of the delta. The silt of the Kistna river is rich in lime and magnesia and total potash and phosphoric acid, and therefore it would be expected that the soils which come under its influence would materially differ from those not affected. Thus it is found that the coastal soils and those in the centre of the delta are generally clearly demarked and are of the poorest quality. This fact would appear to furnish an argument in favour of the conservation of the river silt.—[J. S.]